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RECONNAISSANCE REPORT

SANTA CRUZ HARBOR, CALIFORNIA
SHOALING STUDY

92-29409

US Army Corps
of Engineers
San Francisco District

May 1992

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13. ABSTRACT (Maximum 200 words)

This report was prepared in response to Section 811 of the Water Resources Development Act of 1986 (WRDA 86) which calls for a study of long-term solutions to the shoaling problems at Santa Cruz Harbor in the interest of navigation. Hazardous navigation conditions at the entrance to Santa Cruz Harbor are the result of: (1) wave activity in the entrance caused by waves breaking over shallow depths adjacent to the entrance channel; and, (2) shoals in the entrance channel which require frequent dredging and also contribute to breaking waves. These conditions are the result of relatively high littoral transport and the harbor's small tidal prism which is insufficient in volume to naturally scour the jettied entrance. The purpose of this study was to evaluate alternatives over and above the without project condition designed to supplement Port District activities. Unfortunately, none of the potential solutions studied was found to be economically justified due to the relatively low magnitude of navigation benefits that would be generated.

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US Army Corps
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South Pacific
Division
630 Sansome St
Rm. 720
San Francisco, CA 94111

Public Notice

RECONNAISSANCE REPORT FOR NAVIGATION IMPROVEMENTS (REDUCTION OF SHOALING) AT SANTA CRUZ HARBOR SANTA CRUZ COUNTY, CALIFORNIA

August 14, 1992

COMPLETION OF STUDIES:

I am pleased to announce that the Reconnaissance Report for Navigation Improvements (Reduction of Shoaling) at Santa Cruz Harbor, California, has been completed and submitted for Washington-level review. This report was prepared in response to Section 811 of the Water Resources Development Act of 1986 (WRDA 86) which calls for a study of long-term solutions to the shoaling problems at Santa Cruz Harbor in the interest of navigation (See Plate 1).

FINDINGS AND RECOMMENDATIONS:

Hazardous navigation conditions at the entrance to Santa Cruz Harbor are the result of: (1) wave activity in the entrance caused by waves breaking over shallow depths adjacent to the entrance channel; and, (2) shoals in the entrance channel which require frequent dredging and also contribute to breaking waves. These conditions are the result of relatively high littoral transport and the harbor's small tidal prism which is insufficient in volume to naturally scour the jettied entrance.

The navigation problems associated with the shoaling conditions at Santa Cruz Harbor threaten the safety of all boaters navigating the entrance channel and have a direct financial impact on the Port District and boating interests operating out of the harbor.

In 1986, the Santa Cruz Port District acquired the 16-inch dredge SEABRIGHT with financial participation by the Federal Government in accordance with an April 1986 Cooperative Agreement between the Department of the Army and the Port District. Under the terms of this agreement, it is the responsibility of the Port District to use the SEABRIGHT for maintaining the dredged depth of the entrance channel, the harbor channel, and the turning basin authorized by Congress. Local ownership and operation of the dredge was designed to give the Port more flexibility and control in scheduling and performing required maintenance dredging.

Presently, the Port District expends over $500,000 annually in dredging about 200,000 cubic yards of sand from the entrance.

Vessel delays, lost income, reduced fish catch, and reduced recreational boating opportunities under shoaled conditions are estimated to have an annual value of about $200,000.

The purpose of this study was to evaluate alternatives over and above the without project condition (Port maintenance dredging using the dredge SEABRIGHT) designed to supplement Port District activities. Almost all of these potential long-term solutions to the shoaling problem at Santa Cruz would reduce the dredging demands placed on the SEABRIGHT, thereby giving the Port District the operational latitude to maintain the authorized channels under a more cost effective dredging plan.

Our studies were conducted to formulate long-term solutions to the shoaling problems at Santa Cruz Harbor by increasing the number of days each year that the entrance channel can be safely navigated. A wide variety of improvements was investigated during the study, both structural and non-structural, and included East-Jetty Sealing, Pipeline Extension, Channel Sand Trap, Offshore Sand Trap, Fixed Jet Pumps, Mobile Jet Pump, Reflective West Jetty, Extended Jetty System, Detached Breakwater, Wave Barrier/Sediment Trap, and West Jetty Sealing. These measures were evaluated in full consideration of their engineering and economic feasibility, their environmental and social acceptance, and the varying degrees of shoaling reduction and reduced maintenance provided.

Unfortunately, none of the potential solutions studied was found to be economically justified due to the relatively low magnitude of navigation benefits that would be generated. Therefore, I have concluded that Federal participation in navigation improvements at Santa Cruz Harbor in the interest of reduced shoaling at the entrance is not warranted at this time and no further studies will be conducted in response to the authorizing act. Although I am not recommending Federal participation at this time in solutions to the shoaling problem at Santa Cruz Harbor, I have identified several small-scale measures in the report to alleviate the problem which are within the capability of the Port to implement on their own. These measures may merit further consideration by the Port in the future.

PUBLIC INVOLVEMENT:

Public participation was provided throughout the study by means of informal meetings and discussions, a public workshop, and user surveys and interviews.

REVIEW PROCESS:

Prior to final approval of the reconnaissance report, the study evaluations and report findings will be reviewed by the Board of

Engineers for Rivers and Harbors, the Chief of Engineers, and the Assistant Secretary of the Army for Civil Works.

The Board of Engineers for Rivers and Harbors was established by the River and Harbor Act of 1902 with a primary function of reviewing feasibility reports and advising the Chief of Engineers. The Board conducts its own independent review and coordinates a review by affected States and other Federal agencies. The board then provides a recommendation to the Chief of Engineers. The Chief of Engineers, in turn, reviews the report and recommendations of the Board and forwards a recommendation to the Secretary of the Army. If the Chief's recommendation is significantly different from the recommendation coordinated with the State and Federal agencies, the States and agencies will be afforded an opportunity to comment further prior to submission of the Chief's report to the Secretary.

VIEWS OF INTERESTED PARTIES:

In accordance with law, the Reconnaissance Report for Navigation Improvements (Reduction of Shoaling) at Santa Cruz Harbor, California, has been submitted to the Washington Level Review Center (WLRC) at Fort Belvoir, Virginia, for management of Washington level review and processing. Interested parties may present written views on the report to the WLRC. Statements submitted should not repeat material previously presented at public meeting by the District or Division Engineers, or contained in their reports, as this information is already available to the WLRC. Information submitted should be new, specific in nature and bear directly on the findings in the report. Written communications should be mailed to the Washington Level Review Center, ATTN: CEWRC-WLR, Kingman Building, Fort Belvoir, Virginia 22060, in time to reach the WLRC by September 14, 1992. If extension of this date is considered necessary, a written request stating the reasons and additional time desired should be mailed to the WLRC soon after the receipt of this notice.

WLRC CONSIDERATION OF VIEWS:

Information furnished by mail is considered just as carefully by the WLRC in its coordination of Washington level review and bears the same weight as that furnished at public meetings; therefore, meetings will be scheduled only when found to be in the public interest. Requests for meetings should be fully supported by reasons why the new material cannot be submitted just as effectively by mail as at a meeting. Copies of information received by mail will not be furnished to other parties. However, such information will be regarded as public information (unless the correspondent requests otherwise) and may be inspected and notations made therefrom by other interested parties in the office of the WLRC.

FINAL BOARD ACTION:

The Board of Engineers for Rivers and Harbors will not take final action on the report until after the expiration date of this notice or after any extension thereof that may be granted, and after full consideration of all information submitted to the WLRC in response thereto.

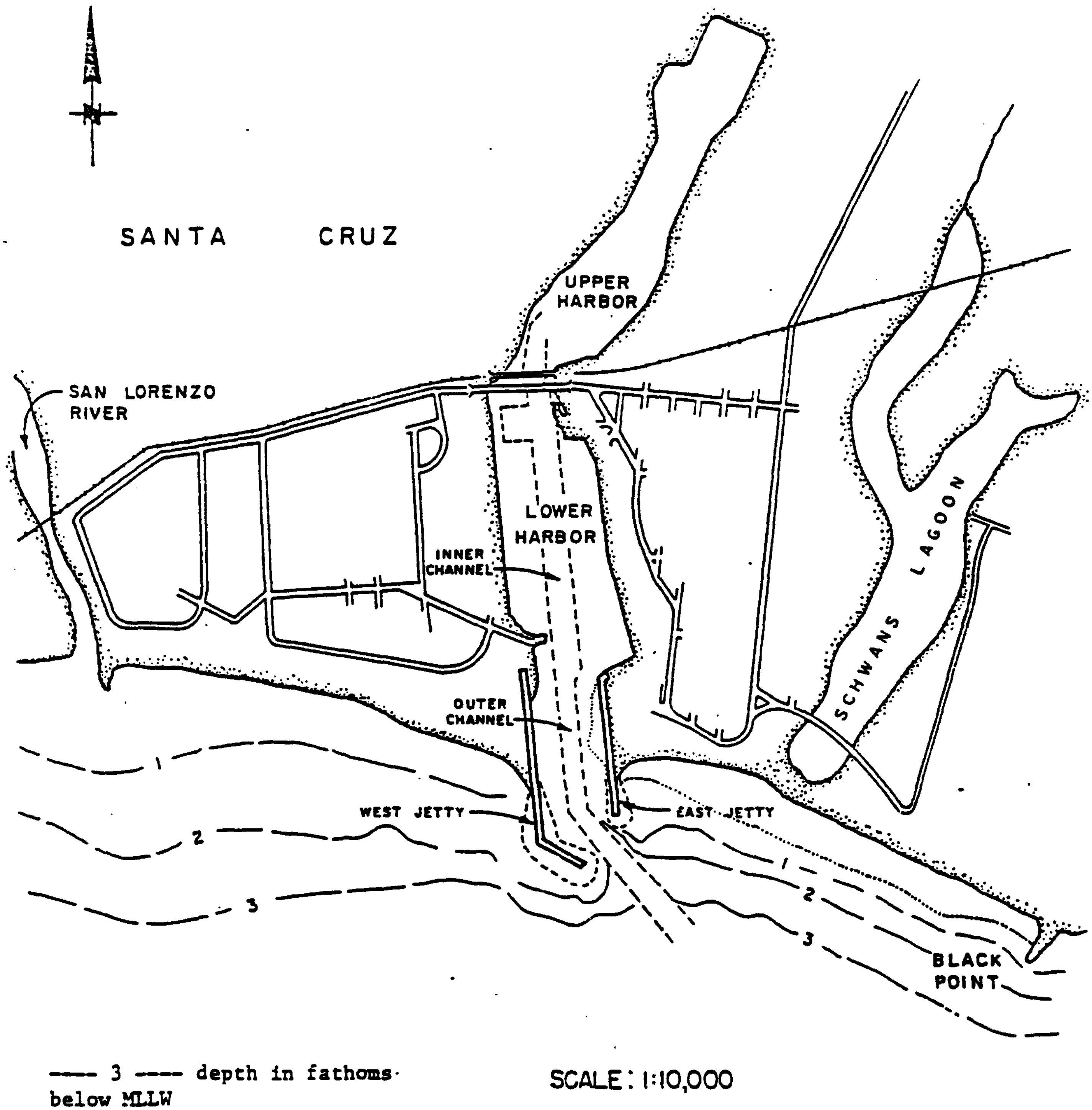
FURTHER INFORMATION:

Further information may be obtained from the office of the District Engineer, U.S. Army Engineer District, San Francisco, 211 Main Street, San Francisco, California 94105. Interested parties, including the media, may make any notes they desire on the contents of the report, though copies of the report will not be loaned for use outside of the office. Interested parties may purchase copies of the report, or parts thereof, including illustrations, at the cost of reproduction ($10.00 for the Main Report and Environmental Assessment). Copies of the report may be purchased from the District Engineer at the San Francisco address cited above. Remittance should be check or money order and made payable to the Treasurer of the United States.

Additional copies of the report will also be on file and available for public review at the libraries listed on Enclosure 2. Please pass along a copy of this public notice to anyone who may be interested in the report and who has not received a copy.

Roger F. Yankoupe
Brigadier General, U.S. Army
Division Engineer

Enclosures



SMALL CRAFT HARBOR

PLATE 1

Enclosure 1

Santa Cruz Harbor Public Notice

List of Libraries

Donald Holtgrieve
Department of Geography
California State University
Chico, CA 95929-0425

Environmental Protection Agency
Library
215 Fremont Street
San Francisco, CA 94105

Environmental Protection Agency
Region IX Library/Information Center
75 Hawthorne Street
San Francisco, CA 94105

Environmental Studies Library
Kerr Hall
University of California
Santa Cruz, CA 95064

Santa Cruz City
County Public Library (9 branches)
Attention: Documents Department
224 Church Street
Santa Cruz, CA 95060

Mr. Gary Griggs
Director, Marine Sciences Institute
University of California
Department of Earth Sciences
Santa Cruz, CA 95064

Water Resources Center, UC Davis
2102 Wickson Hall
University of California
Davis, CA 95616

Water Resources Center Archives
University of California
410 O'Brien Hall
Berkeley, CA 94720

Gordon Smith
Marine Sciences Institute, UCSC
University of California
Santa Cruz, CA 95064

Environmental Information Center
San Jose State University
125 South 7th Street
San Jose, CA 95112

RECONNAISSANCE REPORT

SANTA CRUZ HARBOR SHOALING
GENERAL INVESTIGATION STUDY

SANTA CRUZ PORT DISTRICT
SANTA CRUZ COUNTY,
CALIFORNIA

U.S. ARMY CORPS OF ENGINEERS
SAN FRANCISCO DISTRICT

MAY 1992

SANTA CRUZ HARBOR
SHOALING
GENERAL INVESTIGATION STUDY
RECONNAISSANCE REPORT

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SANTA CRUZ HARBOR SHOALING
GENERAL INVESTIGATION STUDY

RECONNAISSANCE REPORT

1.0 INTRODUCTION

1.1 Study Authority

Authority for this study comes from the Congress of the United States in Section 811 of the Water Resources Development Act of 1986 (PL 99-662) which states:

> "The Secretary (of the Army) shall conduct a feasibility study of the long-term solutions to the shoaling problems in Santa Cruz Harbor and shall report the results of such study, along with recommendations, to the Congress."

1.2 Study Purpose and Scope

The purpose of the study at Santa Cruz is to determine the Federal interest at this time in modifying the harbor project (including dredging practices) to improve navigation and reduce shoaling.

The purposes of the reconnaissance report are to: define problems and opportunities; identify potential solutions; determine whether planning should proceed further into a feasibility phase based on a preliminary appraisal of the Federal interest, cost, benefits, and environmental impacts of the identified potential solutions; estimate time and costs for the feasibility phase, if applicable; and assess the level of interest and support of the non-Federal interests in the identified potential solutions.

1.3 Local Coordination

The local sponsor for this study is the Santa Cruz Port District. The primary contact person has been the Harbormaster. A public workshop was held on 16 July 1991 at which Federal and local agencies, as well as interested parties and individuals, were invited to voice their opinions on the problem and the types of solutions being considered. Additional public input was obtained through a "social environment" study in which in-depth interviews were conducted with individuals, organizations and businesses that use the harbor, are affected by the harbor, and/or have participated in research or planning for the harbor.

1.4 Prior Studies and Reports

There have been a number of Corps of Engineers studies and reports on Santa Cruz Harbor. The pertinent documents are summarized in the following table.

TABLE 1.1

PRIOR REPORTS

Report/Document	Scope of Recommendation	Work Authorized By River and Harbor Act
San Lorenzo River, California Preliminary Examination for Navigation; 21 April 1938	Navigation investigation at mouth of San Lorenzo River at Santa Cruz. Recommended no improvement.	N.A.
Santa Cruz Harbor California; Survey Report for Navigation; 27 February 1958	Survey Report to determine advisability of providing a harbor for light-draft vessels. Recommended improvements, including sand bypassing plant, if required.	3 July 1958
Santa Cruz Harbor, California, Design Memorandum No. 1; December 1960	N.A. (Designed improvements described in House Doc 357, 85th Congress, 2nd Session, 3 July 1958)	3 July 1958
Detailed Project Report, Extension of Existing Small Craft Harbor, Santa Cruz, California; October 1970	Section 107 Study of harbor extension into Woods Lagoon. Recommended improvement.	N.A. (constructed by local interests)
Office Report, Santa Cruz Harbor Sand Bypassing Plant, Santa Cruz County, California; August 1971	Investigation of various sand bypassing methods. Recommended hydraulic dredge acquisition.	3 July 1958 (carried out briefly as a provision of 1958 Act)
Office Report, Santa Cruz Harbor Sand Bypassing Plant; 13 February 1974	Evaluation of possible sand bypassing systems. Recommended jet-pump bypassing.	3 July 1958 (carried out as an experiment and as a provision of 1958 Act)
Interim Dredging Program for Santa Cruz Harbor, California, Moffatt & Nichol, Engineers; November 1977	Consultants report. Recommended periodic dredging with dredge stationed in harbor from November through May.	N.A.

TABLE 1 (Cont'd)

Report/Document	Scope of Recommendation	Work Authorized By River and Harbor Act
Santa Cruz Harbor Shoaling Study, Santa Cruz Harbor, California, Moffatt & Nichol, Engineers; June 1978	Consultants report investigating shoaling solutions. Included evaluations by the Corps' Tidal Hydraulics Committee. Recommended a phased dredging program (either by contract or dredge acquisition) or periodic dredging of a sand trap created by construction of an offshore breakwater.	N.A. (Contract phased dredging implemented as an interim measure)
Cooperative Agreement Between the Department of the Army and the Santa Cruz Port District; 2 April 1986	Agreement to acquire Dredge Seabright and provide Port District with a relatively continuous dredging capability.	3 July 1958 (a provision of 1958 Act)

1.5 Report Organization

1.5.1 Report Sections

This report is divided into 8 sections.

1 - INTRODUCTION. This section presents an overview of the study's authority, purpose and scope, local coordination, prior studies and reports, and report organization.

2 - STUDY AREA DESCRIPTION. Presented in this section is the project location, project description and history, land use, development, and demographics.

3 - PROBLEM IDENTIFICATION. Included in this section is a statement of the problems, the local needs and desires, the national objective, and the planning objectives for this study.

4 - PLAN FORMULATION. Presented in this section is the plan formulation rationale used for the development of the alternative plans. The alternative plans developed to address the planning objectives are discussed along with the local views and preferences. The benefits and costs are identified for the primary alternatives, as well as the implementation responsibility for any plan meriting further study in a feasibility phase.

5 - TECHNICAL CONSIDERATIONS. This section presents the design, economic and environmental considerations associated with the primary alternatives.

6 - COORDINATION, PUBLIC VIEWS AND COMMENTS. This section provides a discussion of the public involvement that occurred during the study.

7 - CONCLUSIONS. This section presents the conclusions drawn from the results of the study.

8 - RECOMMENDATIONS. This section presents the recommendations made based on the conclusions of the study.

2.0 STUDY AREA DESCRIPTION

2.1 Project Location

Santa Cruz Harbor (Figures 2.1 and 2.2) is located in Santa Cruz County, about 70 miles south of San Francisco. The harbor is situated at the northern end of Monterey Bay, between Point Santa Cruz and Soquel Point.

Monterey Bay is a large, semi-elliptical body of water open to the Pacific Ocean on the west; hence, to varying degrees, shoreline locations are exposed to waves arriving from several directions. An important feature of Monterey Bay is the Monterey Submarine Canyon. The deep trough of the North Pacific Basin south of the Mendocino sea scarp approaches closer to shore at Monterey Bay than at any other point along the North American coastline. Near the southern portion of the bay, the 1000-fathom contour comes within 15 miles of the shore.

The harbor is situated in an area of relatively high net littoral transport (between 300,000 and 500,000 cubic yards (cys) per year from west to east). This transport is the primary contributor of sand to the harbor entrance (Figure 2.3).

2.2 Project Description and History

Construction of Santa Cruz Harbor was authorized by Congress under the River and Harbor Act of 1958 by House Document No. 357, 85th Congress, 2nd Session which provided for a harbor for light-draft vessels in Woods Lagoon. The authorized improvements included two rubble-mound jetties 1,200 feet long and 810 feet long, on the west and east sides of the harbor, respectively, as well as associated interior channels.

Federal participation was justified because the improvements would increase food supplies, reduce damages and operating costs of commercial fisheries, and increase the health and welfare of the people.

Construction of the harbor was initiated in February 1963; work then began on the east jetty, and it was completed in April 1963. The entrance channel was dredged to project dimensions in the summer of 1963. All project construction was complete by November 1963 with the exception of the sand bypassing plant, which was deferred until such time as the need and magnitude of the need could be more accurately determined.

The Project Document specified that local interests were to contribute 35.1% of the first cost of the bypassing/maintenance plant and assume all operations and replacement costs in excess of a $35,000 annual limit on Federal maintenance assistance upon completion of the project.

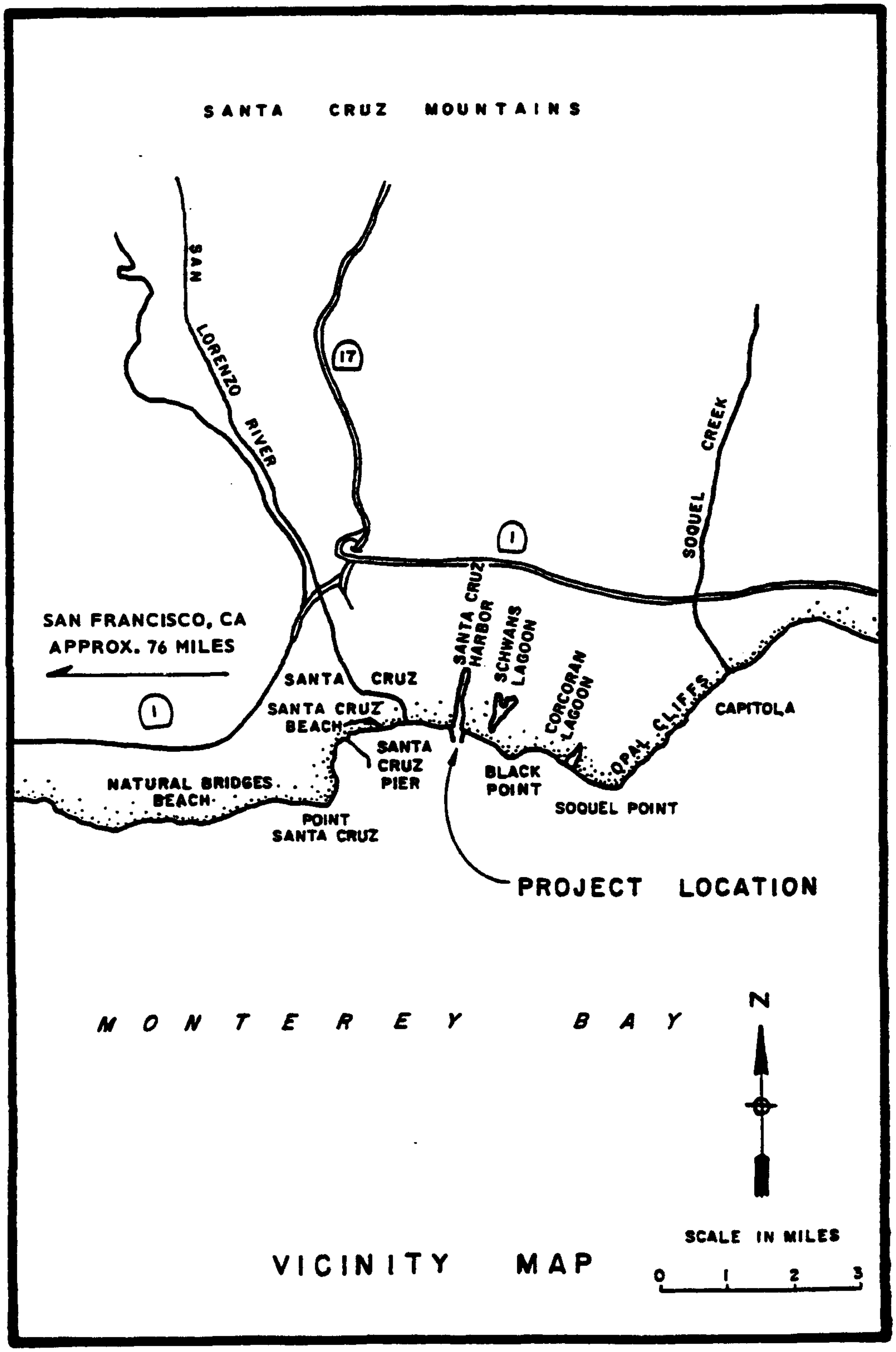
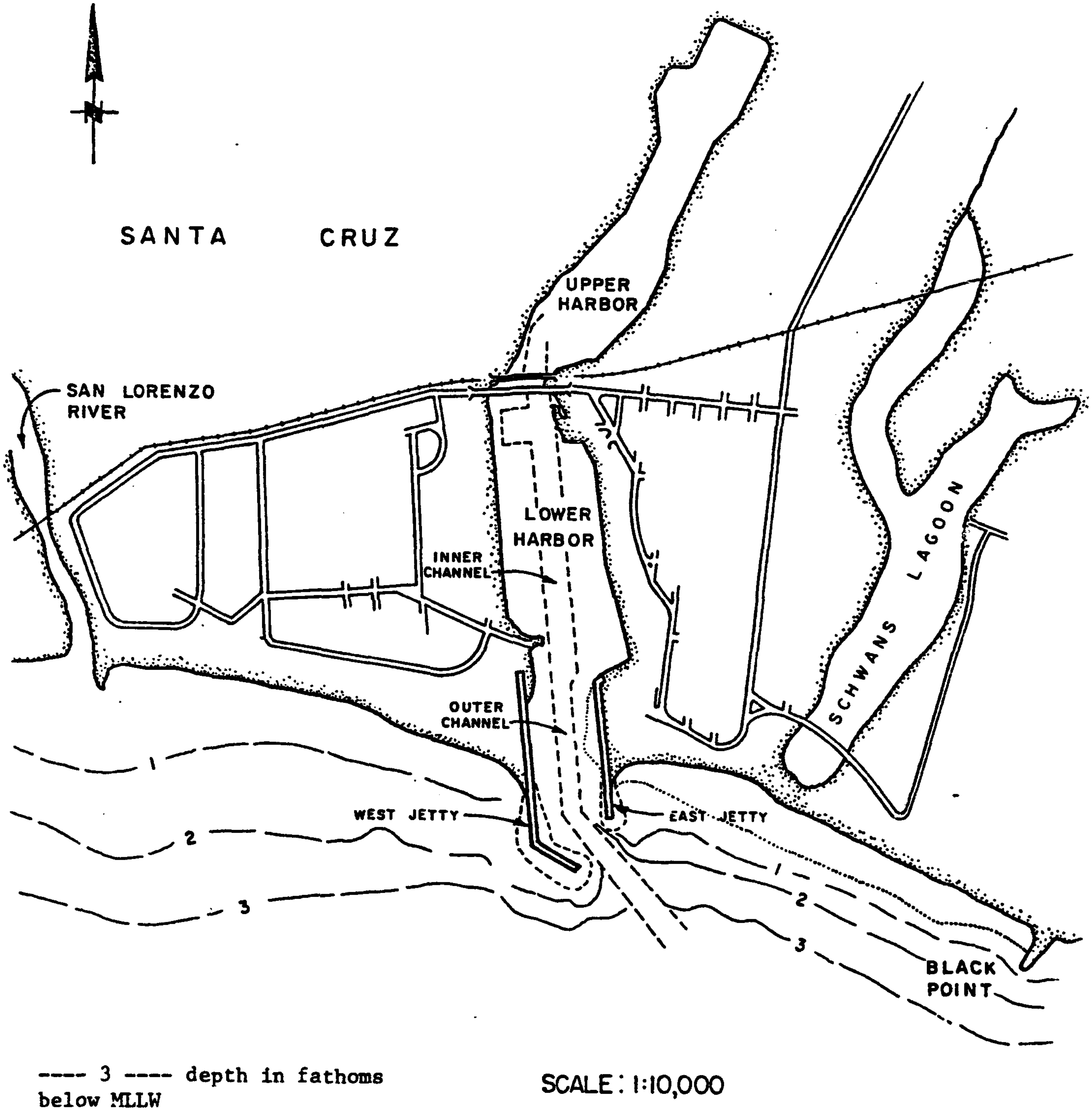
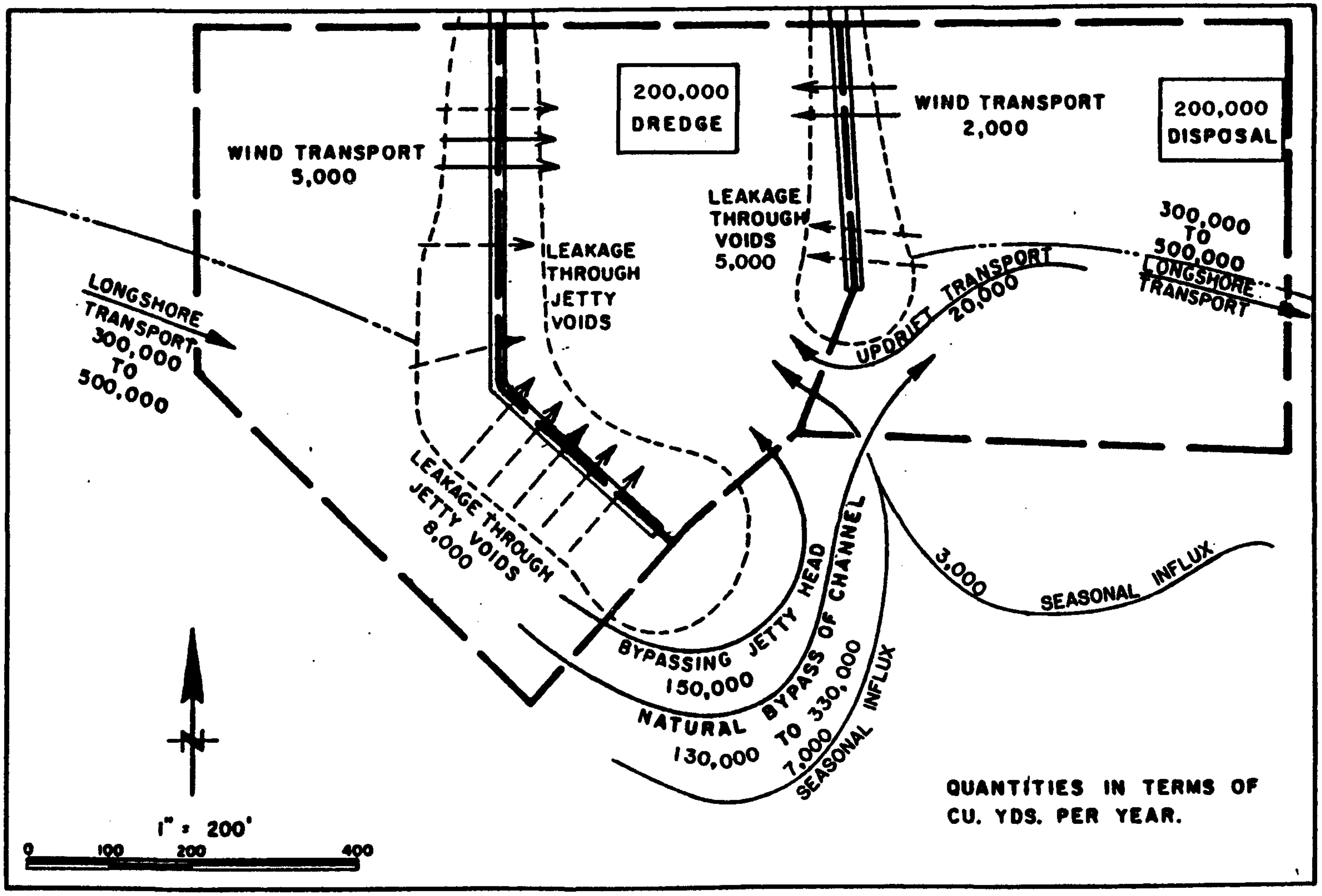

SANTA CRUZ MOUNTAINS
SAN LORENZO RIVER
17
SOQUEL CREEK
1
SAN FRANCISCO, CA
APPROX. 76 MILES
SANTA CRUZ
SANTA CRUZ HARBOR
SCHWANS LAGOON
CORCORAN LAGOON
OPAL CLIFFS
CAPITOLA
1
SANTA CRUZ BEACH
SANTA CRUZ PIER
BLACK POINT
SOQUEL POINT
NATURAL BRIDGES BEACH
POINT SANTA CRUZ
PROJECT LOCATION
MONTEREY BAY
N
VICINITY MAP
SCALE IN MILES
0 1 2 3

FIGURE 2.1



SMALL CRAFT HARBOR

FIGURE 2.2



SEDIMENT BUDGET
SANTA CRUZ HARBOR ENTRANCE

FIGURE 2.3

In the mid-sixties, the beach west of the jetties became a large sand trap for what was estimated to be around 300,000 cubic yards of annual downcoast sand transport. As the sand trap filled, maintenance requirements began to increase and harbor closures became frequent.

Maintaining the harbor had quickly become a challenge to both the Federal Government and to the Santa Cruz Port District.

Most of the dredging at Santa Cruz has been accomplished by Government contracts. Twice, however, the Federal Government helped the Port District acquire a dredge so that the maintenance work could be accomplished on a more continuous basis by the local interests. The first such occurrence was in the early 1970's when the dredge Santa Cruz was procured. This 12-inch hydraulic dredge quickly proved inadequate for the job, being too small and unstable for work in rough conditions. The second occurrence was in 1986 when the 16-inch dredge Seabright was acquired. This dredge has proved to be very capable and continues to work the harbor entrance. Acquisition of the Seabright was cost shared based on the original Project Document with the current capitalized value of the authorized annual $35,000 Federal contribution being paid up front. This, in turn, relieved the Corps of Engineers of operations and maintenance (O&M) responsibilities in the harbor entrance, at least until the cost-sharing agreement expires in the year 2013.

The acquisition of the Seabright was the result of a Port District proposal presented at a meeting in 1984 between the Assistant Secretary of the Army for Civil Works, the Corps of Engineers, and the Port District. Discussion centered on ways to reduce high O&M costs and solve the shoaling problem at Santa Cruz. Two other needs identified at that meeting were for the evaluation of long-term solutions to the shoaling problem and to seal the east jetty. These two actions were subsequently authorized in the Water Resources Development Act of 1986. Funds have not been appropriated for jetty sealing. In 1991, however, Congress did appropriate funds for the present shoaling study which is being carried out under the two-phase study process.

2.3. Land Use, Development, and Demographics

Santa Cruz Harbor encompasses about 34 acres of water area and is used for both recreational and commercial interests. Approximately 1100 vessels dock in the harbor, roughly 20% are commercial fishing vessels.

The Santa Cruz Port District is an independent agency created in 1950 under provisions in the Harbors and Navigation Code of the State of California. The District is governed by a board of five commissioners who are elected at large by voters residing in the Port District. Revenue from slip rentals, user fees, and concessions fund 90% of the District's operating budget. The remaining ten percent comes from property taxes.

The City of Santa Cruz is heavily marine oriented. It's central business district and the waterfront are bisected by the course of the San Lorenzo River which enters the Pacific Ocean just north of Santa Cruz Harbor. Marine research, commercial fishing, and water-related recreation are prominent activities.

The mild climate and scenic beauty of Santa Cruz, combined with the richness and variety of marine life in Monterey Bay, attract visitors and commerce from the central California area.

The growth of the City of Santa Cruz is typical of the region, with a population of 26,000 in 1960, expanding to over 50,000 in 1990. Ethnicity in 1990 was: 79% White; 13.6% Hispanic; 4.4% Asian/Pacific Island; and 2.1% Black. The City has estimated that in 1991 its recreation and park facilities served a population of over 100,000 people, and has estimated the tourist population to be 2.5 million annually.

3.0 PROBLEM IDENTIFICATION

3.1 Statement of the Problem

Safe navigation at Santa Cruz Harbor is limited in two ways: (1) shallow conditions adjacent to (west of) the entrance channel initiate wave breaking which can carry into the channel; and (2) shoals in the entrance channel itself require frequent dredging and contribute to entrance wave breaking. These conditions are caused primarily by relatively high littoral transport which has produced significant growth of the west beach and, to a lesser extent, growth of the east beach since jetty construction, and by the inability of the harbor's small tidal prism to scour the entrance channel.

The jetties at Santa Cruz are only about 400 feet apart and impoundment of littoral drift has significantly reduced their effective length. Originally the west jetty extended about 800 feet from the shoreline while the east jetty was offset about 400 feet from the shoreline. Natural depths at the time of construction were 18 feet mean lower low water (MLLW) at the seaward end of the west jetty and 14 feet MLLW at the seaward end of the east jetty. The rate of littoral transport was not known and was only generally defined as being between 25,000 and 300,000 cubic yards (cys) per year to the east. Shortly after construction it became apparent that the actual transport rates equalled or exceeded the upper limit of the suggested range as the shoreline rapidly advanced seaward to within 300 feet of the end of the west jetty and to within 200 feet of the end of the east jetty.

When the original design was developed, such shallow conditions and the resultant wave focussing and entrance wave breaking were not anticipated. However, it was acknowledged by the Chief of Engineers that, since neither the actual rate of littoral drift at the harbor site nor the impounding capacity of the west jetty could be accurately predicted at that time, the project "should provide for sand bypassing as may be necessary to supply sand to the downdrift shore at the existing normal rate by such methods as the Chief of Engineers may determine to be the most suitable ... that prospective beach erosion damages would greatly exceed the bypassing cost, and that bypassing is the least expensive method of averting these damages."

Bypassing at Santa Cruz has been essentially limited to in-channel dredging. Initially, this practice limited the amount of dredging required. As the trapping capacity upcoast of the west jetty was reached, the amount of sand entering the harbor increased. The bypassing of channel sands then began to more closely duplicate the natural transport of sand in the region. Were a plant built to maintain both the channel and the original upcoast shoreline, more sand would have been manually bypassed and this could have helped reduce entrance wave breaking hazards. Under present conditions, even when the entrance channel is at its authorized dimensions (20 feet deep, 125 feet wide between the

jetty heads), hazardous conditions may still exist due to waves breaking adjacent to the entrance and peeling across the harbor mouth. Typical and extreme entrance breaking conditions are shown in Photographs 1 and 2, respectively. Eight- to ten-foot-high breaking waves in the entrance have been documented on video tape as recently as 29 January 1992. Fatalities have been attributed to such conditions in the past.

These conditions have had a financial impact on the harbor and its users. Presently, over $500,000 is spent annually to dredge around 200,000 cubic yards of sand from the entrance and navigation impacts (delays, reduced fish catch, etc.) are estimated to have an annual value on the order of $200,000. For more information on the navigation problems at Santa Cruz Harbor, see the discussions on existing conditions ("no action" alternative) and economic impacts in Chapter 5.

3.2 Local Needs and Desires

Essentially, the local needs and desires are to have the problems identified in Section 3.1 addressed. An example of harbor user concern over the entrance condition is expressed in the letter from Bill Lee of Bill Lee Yachts contained in Appendix A (Pertinent Correspondence).

Interviews with harbor users conducted for the Social Environment Study (Appendix D) and economic impact surveys conducted by the Port District revealed that many users felt the entrance problems were serious enough to warrant some type of improved solution. Many, however, were content with the current maintenance practice and saw little point or promise in investigating different solutions.

The Santa Cruz Port District also expressed concern over the surge problems which periodically plague the back of the harbor. Strictly speaking, surge is not an objective of the shoaling study but, to the extent that modifications to the harbor entrance can affect surge and seiche conditions in the harbor, the surge problem has been described with a simple model (see Appendix B).

Much of the comment received at the public meeting was from downcoast property owners. They expressed concern over the impacts of the harbor on downcoast erosion. While this is not an authorized feature of the shoaling study, some of the data collected for this study on adjacent shoreline histories (necessary for projecting any possible change in shoaling; see Appendix B) is of recognized value in the study of downcoast impacts.

3.3 National Objective

The objective of Federal projects is to formulate solutions which alleviate problems and take advantage of opportunities in ways that contribute to the National Economic Development (NED). Contributions to the NED are increases in the value of the national

output of goods and services. The NED objective must be accomplished without unreasonable adverse effects to the environmental quality of the area under study. The plans formulated during this reconnaissance study take advantage of opportunities in ways that contribute to the NED objective.

3.4 Planning Constraints

The constraints affecting the formulation of solutions to the shoaling problems at Santa Cruz Harbor reflect concerns expressed by the Port District, harbor users, and other local interests. These constraints are as follows:

(1) Preserve the transport of much needed sand to downcoast beaches;

(2) Recognize the protected environments of the Monterey Bay National Marine Sanctuary; and

(3) Minimize impacts to beach use on Seabright and Twin Lakes Beaches during the high demand period betweer June and September.

3.5 Planning Objectives

The following planning objectives have been used in the formulation of solutions to the shoaling problems at Santa Cruz Harbor:

(1) Increase the number of days each year that the entrance to Santa Cruz harbor can be safely and efficiently navigated through (a) improved channel depths relative to that presently obtainable with the dredge Seabright, and/or (b) reduced wave breaking adjacent to the channel; and

(2) If possible (in conjunction with Objective 1), reduce the annual cost of maintaining the channel as a result of (a) reduced sand volumes reaching the channel, and/or (b) more reliable or cost-effective means of removing channel sands.

4.0 PLAN FORMULATION

4.1 Description of Alternatives

The constraints and objectives outlined in Section 3.4 and 3.5 have been used to formulate and evaluate a variety of project alternatives. The primary alternatives considered are described in Section 4.1.1; additional alternatives are described in Section 4.1.2. The primary alternatives are given further analysis in subsequent sections of this report; the "additional" alternatives were recognized as having little promise and are, therefore, given a brief evaluation in Section 4.1.2 and no further discussion in subsequent sections of this report.

4.1.1 Primary Alternatives

With the exception of No Action (Alternative 1) and East Jetty Sealing (Alternative 2), all of the primary alternatives considered are non-structural and involve additional dredging or dredging practice modifications judged to be beyond the Port District's requirements under the 1986 Cooperative Agreement through which the dredge Seabright was acquired. The seven primary alternatives are presented on Plates 1-7 and are described below. To varying degrees, each alternative addresses Objective 1 (improve entrance navigation). Some alternatives also address Objective 2 (reduce channel maintenance costs). The focus of each primary alternative is summarized in Table 4.1.

Alternative 1: No Action. The no action alternative (Plate 1) implies no change to the present maintenance practices or entrance conditions at Santa Cruz Harbor. As stated in the April 1986 Cooperative Agreement between the Department of the Army and the Santa Cruz Port District (Appendix A), it is the responsibility of the Port District to use the dredge Seabright for "maintaining the dredged depth of the entrance channel, the harbor channel, and the turning basin authorized by Congress." It is, therefore, assumed that this ongoing Port District responsibility represents the "no action" or "without project" condition for the current study. The other alternatives considered address actions that are judged to be beyond the purview of the Port's legal responsibility under the 1986 agreement.

Alternative 2: East Jetty Sealing. This alternative (Plates 2a-2d) would attempt to limit the transport of sand into the channel through the jetty by sealing the east side slope of the jetty between Stations 3+50 and 7+00 with concrete grout and placing tremied concrete along the centerline of the jetty from Stations 7+00 to 7+95.

Alternative 3: Pipeline Extension. This alternative (Plate 3) would attempt to reduce the amount of dredged sand which re-enters the harbor during westerly transport events. An additional 800 feet of discharge pipe would be deployed so that dredged sand may

TABLE 4.1
SANTA CRUZ HARBOR SHOALING STUDY

FOCUS OF PRIMARY ALTERNATIVES

		TARGET OBJECTIVE: 1. IMPROVED NAVIGATION (via)		2. REDUCED CHANNEL MAINTENANCE COSTS (via)	
ALTERNATIVE	DESCRIPTION	Improved Channel Depths	Reduced Wave Breaking Adj. to Channel	Reduced Sand Reaching Channel	Potentially More Reliable/Effective In-Channel Methods
1	No Action	N.A.	N.A.	N.A.	N.A.
2	East Jetty Sealing	X		X	
3	Pipeline Extension	X		X	
4	Channel Sand Trap	X			
5	Offshore Sand Trap	X	X	X	
6	Fixed Jet Pumps	X			X
7	Mobile Jet Pump	X	X	X	

be discharged up to 1250 feet east of the east jetty . A permanent manifold type pipeline system was initially anticipated for this alternative, allowing for disposal at a variety of points on the beach up to 1250 feet east of the entrance. This would have been beyond the purview of the Port's legal responsibility under the 1986 agreement. This, however, was soon recognized as cost ineffective. The most economic approach is not a permanent one, but one that would involve extending pipe easterly over the course of the dredging season in increments laying each new section only after the beach had become sufficiently wide to allow pipe placement on high ground. While this alternative has been analyzed using this more economic approach, the Port District was provided with sufficient pipe in 1986 and any implementation is judged to be within the Port District's realm of responsibility.

Alternative 4: Channel Sand Trap. This alternative (Plates 4a-4e) would attempt to increase the sand storage capacity of the harbor by regularily dredging to a depth of -40 feet MLLW between channel stations 16+50 and 19+50. This work would be accomplished using the Seabright and additional labor shifts.

Alternative 5: Offshore Sand Trap. This alternative (Plates 5a-5h) would use a hopper or clam shell dredge at the beginning of each dredge season to dredge an excavation 2000 feet long roughly along the 25-foot isobath and landward to the 15-foot isobath in front of the west jetty and the harbor entrance. This excavation is expected to reduce wave heights at the entrance as well as the amount of sand entering the harbor each year. Annually, up to 200,000 cubic yards of sand would be removed from the shoal area in front of the harbor and disposed of one mile to the east in a one-third mile long area between the 15-foot and 20-foot isobaths near Corcoran Lagoon. This disposal site is expected to be dispersive and close enough to shore to keep the sand in the downcoast littoral system.

Alternative 6: Fixed Jet Pumps. This alternative (Plates 6a-6d) would locate jet pumps or eductors in the entrance channel to serve as all-weather supplements to the existing dredge system. The jet pumps are presumed to be capable of maintaining the harbor at times when weather conditions are unfavorable or unsafe for operating the floating dredge. If additional pumps are located outside the channel, breaking waves adjacent to the channel may also be reduced somewhat. Sand excavated by the jet pumps would be pumped on to the east beach through an additional pipe running parallel to the dredge pipe currently in use.

Alternative 7: Mobile Jet Pump. This alternative (Plates 7a-7c) attempts to bypass sand to the east beach before it can accumulate in the harbor. This is also hoped to reduce breaking waves adjacent to the channel and is accomplished by deploying a jet pump or eductor nozzle from a mobile crane operating in the intertidal zone on the west beach (Seabright Beach). As in Alternative 6, the sand excavated by the jet pump would be pumped

on to the east beach (Twin Lakes Beach) through an additional pipe running parallel to the dredge pipe currently in use.

4.1.2 Additional Alternatives

The following alternatives were also considered but were recognized as having little promise. All of these "additional" alternatives are structural (i.e. jetty extensions, detached breakwaters, etc.) and are infeasible primarily because of cost and environmental impacts.

Reflective West Jetty. This alternative involves sealing the seaward face of the dogleg on the west jetty or constructing a small spur-like reflective structure off the seaward side of the dogleg. The intent of such a modification would be to deflect sands seaward in hopes that they would stay in the littoral system and naturally bypass the harbor entrance. However, such a modification may not produce the desired effect and is likely to produce several adverse ones. A 100% reflective structure is not absorbent or compliant and, as such, experiences significant slamming forces from waves. Furthermore, reflection from the structure may cause scour at the structure toe. In addition, any deflected sands may be deflected right into the entrance or, possibly, beyond the littoral zone which could lead to downcoast impacts. Finally, for the structure to be effective, reflection from it would have to set up a short-crested wave field which represents a significant navigation hazard. For these reasons, no further consideration was given to this alternative in the recon phase.

Extended Jetty System. This kind of solution, when done in conjunction with a sand bypassing system which moves sand directly from the west beach to the east beach, will keep sand out of the harbor, but it is much too costly. The cost of adequate extensions and a fixed bypassing plant capable of moving up to roughly twice that required of the present dredge (since more of the longshore drift would be impounded by the extended jetties) would be well over $10 million, which is an order of magnitude greater than the level of anticipated benefits. For this reason, no serious consideration was given to this alternative in the recon phase.

Detached Breakwater. A detached breakwater, located upcoast of the harbor, can be used to create a protective shadow in which sand will deposit prior to reaching the harbor. This type of solution is best suited for areas where sand can be allowed to accumulate over longer periods before it must be dredged and moved downcoast. To avoid downcoast impacts, the dredge would have to continuously operate behind the breakwater during winter. This requires a long breakwater (on the order of 1,000 feet) to ensure adequate protection for the dredge. The cost of such a breakwater would be in excess of $10 million, which again is an order of magnitude greater than the anticipated level of benefits. For this reason, no serious consideration was given to this alternative in the recon phase.

Wave Barrier/Sediment Trap. This concept is closely related to the detached breakwater but tailored somewhat. A short (200 feet or so) wave barrier or baffle-style breakwater is constructed as a hooked extension of the west jetty to provide additional protection for the dredge so that it can safely operate just beyond the harbor entrance. This type of barrier is a pile-supported wall which penetrates below the water surface enough to cut off much of the incoming wave energy but allows a vertical gap of, say, five feet off the seafloor through which water and sand can freely travel. A five-foot tall gap in twenty feet of water would allow about 50% of the incoming wave energy to reach the lee side for a typical 17-second wave. Such a reduction would significantly improve wave conditions and shoaling at the entrance while causing sand to drop out in the lee of the structure where the dredge can safely collect it.

Such a structure, however, has never been used as a sediment trap, nor has it been used in a wave climate as severe as that at Santa Cruz. Applications to date have not included open ocean swell locations and have been limited to wave heights and periods of less than ten feet and six seconds, respectively. A structure at Santa Cruz would have to be designed for wave heights in excess of 15 feet. This would require a massive truss-like design estimated to cost nearly $3 million. This cost is at least 50% greater than the value of any anticipated benefit. Furthermore, since the wall extends seaward of the jetty, some of the sand presently bypassing the jetty would be trapped and annual dredging requirements thereby increased. For these reasons, no further consideration was given to this alternative during the recon phase.

West Jetty Sealing. A certain amount of sand reaches the harbor by leaking through the permeable jetties. In establishing the harbor sediment budget (see Appendix B), Moffatt & Nichol (1992) estimated 8,000 cys per year leak through the west jetty.

The west jetty was previously sealed with grout. The outer portion (including the dogleg) was grouted on two-foot centers and has a relatively well chinked-in core so leakage is substantially reduced. This part of the jetty is perhaps 80% sealed, the landward portion, which was only sealed on four-foot centers, is perhaps 40% sealed. More effective sealing of the west jetty is possible. However, if a more effective seal were accomplished, much of the sand that presently leaks through the west jetty would still be likely to enter the harbor via the tip shoal (a more challenging area to dredge). Therefore, there is little incentive to further seal the west jetty. Note that for the east jetty, there is less concern that "sealed out" sands could subsequently enter the harbor via the formation of an east jetty tip shoal. Therefore East Jetty Sealing has remained a primary alternative.

4.2 Local Views and Preferences of Study Alternatives

All study alternatives have been developed through continued coordination with the Santa Cruz Port District, the local sponsor for the study. The Port District comments on the primary alternatives being considered (with the exception of Alternative 5) are summarized in the 14 November 1991 Port District letter contained in Appendix A. Alternative 5 (the Offshore Sand Trap) was not addressed in the 14 November 1991 correspondence because it was not considered a primary alternative at that time. As initially formulated, the offshore sand trap was a smaller feature to be excavated by the Seabright. Accordingly, the Port District expressed concern over extended use of the Seabright in unsheltered offshore areas. As Alternative 5 is now formulated (a large area being excavated rapidly by a larger contract dredge), the Port District is once again supportive of an offshore sand trap.

In general, the Port District is supportive of all of the primary alternatives. Support for Alternatives 3 and 4, however, is somewhat qualified. Alternative 3 (Pipeline Extension) is acknowledged by the Port District as something requiring little further Corps study if the most economic approach involves a minimal modification to their present dredge disposal practice and not a permanent engineered pipeline. Similarly, support for Alternative 4 (Channel Sand Trap) was only in the context of a "new Federal channel" or advanced maintenance prism being authorized; otherwise, it was acknowledged that the Port District could simply create limited sand traps in the channel as another minor modification to their present practice. Because of various environmental concerns, the Port District was unsupportive of incorporating any clay excavation into Alternative 4. Accordingly, it is tentatively assumed that all excavation for the channel sand trap is to be above the clay layer. In recommending further study of the jet pump alternatives, the Port District also encouraged Corps' use of Santa Cruz Harbor as a site for further experiments with jet pumps.

Evaluation of all plans relative to the "no action" alternative, as defined in Section 4.1.1, was questioned by the Port District. In a letter to the study manager dated 5 May 1992, the harbormaster, reiterating concerns expressed at a previous meeting, stated:

> "We questioned whether or not it was accurate to use the 1986 conditions (post-Seabright) for the basis of the benefit/cost analysis for the west shoal problem. We proposed that 1958 would be more logical as the acquisition of the Seabright was never intended to deal with the problems of the west shoal. This is a problem which has generated since 1963 and the construction of the west jetty."

The Corps position is as stated in Section 4.1.1; the Port District has an ongoing responsibility to operate the Dredge Seabright for channel maintenance. The economics of acquiring the Seabright are not revisited as part of this study. However, reduced use of the Seabright is a claimed benefit for certain alternatives. Furthermore, elimination of the "west shoal" or west beach fillet cannot be accomplished by the Seabright, therefore, alternatives formulated to eliminate this upcoast feature do so by other means. As such, the benefits attributed to them are in no way "diluted" by the presence of the Seabright.

Economic impact surveys collected by the Port District and interviews conducted with harbor users for the Social Environment Study (Appendix D) indicate that most of those surveyed were generally supportive of the primary alternatives under consideration. On the other hand, many did not wish to have the Port District invest in anything that was unproven and expressed strong support for the "no action" alternative.

Additional alternatives were also suggested by several of the surveyed local interests. Typically these suggestions were for consideration of structural alternations which were already judged to be cost prohibitive. One suggestion, however, was quite practical, namely to construct "snow" or "dune" fencing along the west side of the west jetty to reduce the amount of wind blown sand entering the channel. This is a very cheap solution that does not merit any Federal study and could eliminate about 5,000 cubic yards of dredging (see Figure 2.3).

4.3 Evaluation of Primary Alternatives

The benefits and costs of each primary alternative have been estimated and are presented in Table 4.2 through 4.7. The tabulated values are based on design, operation, effectiveness and benefit assumptions outlined in Section 5. Project cost estimates are contained in Appendix F. An additional cost for Engineering and Design (E&D) as well as Supervision and Administration (S&A) has been added where appropriate. Lands, Easements and Rights-of-Way values are derived in Appendix G. The following paragraphs briefly summarize the evaluation of each alternative.

Alternative 1: No Action. The existing condition or "no project" alternative does not meet the planning objectives outlined in Section 3.4. All other alternatives are contrasted with Alternative 1, i.e. the benefits determined for each of the other alternatives are based on the anticipated changes in cost, or income loss, relative to the existing condition which would result from implementing the alternative.

Alternative 2: East Jetty Sealing. This alternative (Table 4.2) is estimated to reduce the annual quantity of sand reaching the harbor by about 5,000 cubic yards, providing minimal navigation improvements and about $7,000 in annual benefits from reduced maintenance costs. This benefit is well below the

estimated annualized cost of $31,500. An authority to make such a seal was provided for under the Water Resources Development Act (WRDA) of 1986 but has not been pursued because of uncertainty as to whether sealing would prove to be sufficiently beneficial. Given the apparent lack of justification for sealing, this alternative is not a good basis for recommending further (feasibility) study under the operant study authority. However, the existing WRDA 1986 authority may be renewed in WRDA 1992 (see the Congressional letter of support in Appendix A).

Alternative 3: Pipeline Extension. This alternative (Table 4.3) is estimated to reduce the annual quantity of sand reaching the harbor by roughly 10,000 cubic yards, providing minimal navigation improvements and about $14,000 in annual benefits from reduced maintenance costs. This benefit is less than the estimated annualized cost of $33,800. Most of this annualized "cost," however, is simply the value of the proposed harbor land on which the additional pipe would be stored in the off season. Note that the pipe provided under the 1986 agreement is presently being used elsewhere and is not requiring this storage space. In the absence of this "cost," the benefits are roughly twice as great as the remaining costs.

As previously pointed out, the final formulation of this alternative is such that its implementation is judged to be within the Port District's realm of responsibility. Furthermore, the Port District has acknowledged that they expect little, if any, further Corps study of this alternative.

Alternative 4: Channel Sand Trap. This alternative (Table 4.4) is projected to provide sufficient trapping capacity such that hazardous depths within the channel are virtually eliminated. Neglecting the possible impacts of waves breaking adjacent to the channel, this alternative has been credited with offsetting all the present navigation impacts valued at $194,000 annually. This benefit, however, is well below the estimated cost ($330,000) of the additional 130,000 cubic yards of dredging projected to be necessary for trap maintenance each year. Therefore, it would seem most advisable for the Port District to simply continue with their present practice, i.e. attempting to create a sand trap whenever it can be accommodated within the other priorities for the dredge. In other words, it does not appear advisable to gear up for additional dredge use (i.e. above that already contracted for) for the express purpose of sand trap creation within the channel.

Alternative 5: Offshore Sand Trap. This alternative (Table 4.5) is projected to reduce the occurrence of wave breaking at the harbor entrance (potentially offsetting the present navigation impacts valued at $194,000 annually) and to reduce the amount to sand entering the harbor each year by about 100,000 cubic yards, providing an additional $75,000 in annual benefits from reduced maintenance. This $75,000 figure is a cap on dredge cost savings based on no more than one month of Seabright time being

saved under the present and projected contracting practices. The total annual benefit is $269,000, which is well below the estimated cost of $560,000 for executing the annual hopper or clam shell dredging contract. This alternative is priced out based on disposal at a dispersive site in the nearshore zone in what is understood to be part of the Monterey Bay National Marine Sanctuary. If this disposal practice were not permitted, the more costly practice of double handling the material and pumping it to the beach may be necessary, making this alternative even more cost prohibitive. It should be pointed out, however, that if this alternative were implemented by local interests using a flexible multi-year contract, perhaps incorporating both the Seabright operation and annual hopper/clam shell dredging into one contract, actual costs could come down substantially. Furthermore, if this alternative were implemented, the size of the offshore sand trap could be optimized with time, potentially reducing costs further. However, based on the initial benefit-cost comparison, the Offshore Sand Trap does not have potential as a Federal project.

Alternative 6: Fixed Jet Pumps. This alternative (Table 4.6) is projected to act as enough of an all-weather supplement to the existing dredge system that hazardous depths within the channel would be eliminated. The tabulated cost estimate only reflects the minimum system of two in-channel pumps. Neglecting the possible impact of waves breaking adjacent to the channel, this alternative has been credited with offsetting the present navigation impacts which have been valued at $194,000 annually. In addition, the system is estimated to reduce the amount of sand the Seabright must dredge by 100,000 cubic yards, providing an additional $75,000 in annual benefits. The total annual benefit is $269,000, which is well below the average annual cost of $414,000, suggesting no Federal interest. The Port District, however, has expressed interest in seeing this alternative developed further. Future study is remotely possible under the Corps' Dredging Research Program and Coastal Inlets Research Program. The Corps' Waterways Experiment Station does own a 6-inch jet pump which could be modified to a 500-cy-per-hour capacity in order to run test cases at Santa Cruz. The experimental interest centers around the use of jet pumps as a tool in channel maintenance (as opposed to a pure bypassing application), especially in the challenging kelp and debris environment at Santa Cruz. The emphasis, however, is on experiments. The Fixed Jet Pump system as a project does not appear advisable at this juncture.

Alternative 7: Mobile Jet Pump. This alternative (Table 4.7) is projected to partially reduce wave breaking adjacent to the channel and to reduce the annual quantity of sand reaching the harbor by roughly 50,000 cubic yards, providing a combined navigation improvement and reduced maintenance benefit of a approximately $167,000. This benefit is much less than the estimated annualized cost of $377,000, suggesting no Federal interest. Roughly one fourth of this annual "cost," however, is simply the value of the proposed harbor lands required to store the existing crane and new pipe during the off season. Since the crane

storage area is likely to be maintained with or without the proposed alternative, this area may be considered "dedicated." In spite of this, its value still would be credited to the sponsor were a cost-shared project justified.

4.4 Determination of Preliminary Selected Plan

Based on the preliminary evaluation in this reconnaissance report, there is no Federal interest in Alternatives 2 through 7. The select plan is Alternative 1: No Action.

4.5 Federal-Non-Federal Cost Sharing

With no Federal interest in a new project to reduce shoaling at Santa Cruz Harbor, Federal-non-Federal cost sharing is not applicable. However, based on the Water Resources Development Act of 1986, were a project to reduce shoaling justified, cost sharing for such a project would be on the same basis as the original project to which the shoaling is attributed. For Santa Cruz Harbor, this would suggest a Federal share of 64.9% and a non-Federal share of 35.1%, per the original Project Document.

Table 4.2

SANTA CRUZ HARBOR SHOALING
GENERAL INVESTIGATION STUDY

ANNUAL BENEFIT TO COST COMPARISON
ALTERNATIVE 2: EAST JETTY SEALING

DESCRIPTION	COST
Project First Cost (incl 8% E&D, 7% S&A)	$345,000
Interest During Construction (1/4 yr @ 8.5%)	7,300
TOTAL INVESTMENT COST	352,300
Capital Recovery Factor (CRF) (8-1/2% for 50 years)	(0.08646)
Annualized First Cost	30,500
Annual Operations & Maintenance	1,000
AVERAGE ANNUAL COST	31,500
AVERAGE ANNUAL BENEFIT	7,000
NET BENEFITS	-24,500
BENEFIT TO COST RATIO (B/C)	0.22

Table 4.3

SANTA CRUZ HARBOR SHOALING
GENERAL INVESTIGATION STUDY

ANNUAL BENEFIT TO COST COMPARISON
ALTERNATIVE 3: PIPELINE EXTENSION

DESCRIPTION	COST
Project First Cost (incl 8% E&D, 7% S&A)	$ 23,000
Lands, Easements and Right-of-way (Pipe Storage)	315,000
TOTAL INVESTMENT COST	338,600
Capital Recovery Factor (CRF) (8-1/2% for 50 years)	(0.08646)
Annualized First Cost	29,200
Annual Operations & Maintenance	4,600+
AVERAGE ANNUAL COST	33,800
AVERAGE ANNUAL BENEFIT	14,000
NET BENEFITS	-19,800
BENEFIT TO COST RATIO (B/C)	0.41

+Based on 70 days of mobilization per year requiring one hour of overtime at time and a half from the mate ($22.60/hr) and deck hand ($22.50/hr).

Table 4.4

SANTA CRUZ HARBOR SHOALING
GENERAL INVESTIGATION STUDY

ANNUAL BENEFIT TO COST COMPARISON
ALTERNATIVE 4: CHANNEL SAND TRAP

DESCRIPTION	COST
Annual Operations & Maintenance	$330,000
AVERAGE ANNUAL COST	330,000
AVERAGE ANNUAL BENEFIT	194,000
NET BENEFITS	-136,000
BENEFIT TO COST RATIO (B/C)	0.59

Table 4.5

SANTA CRUZ HARBOR SHOALING
GENERAL INVESTIGATION STUDY

ANNUAL BENEFIT TO COST COMPARISON
ALTERNATIVE 5: OFFSHORE SAND TRAP

DESCRIPTION	COST
Annual Operations & Maintenance (incl 8% E&D, 7% S&A)	$560,000
AVERAGE ANNUAL COST	560,000
AVERAGE ANNUAL BENEFIT	269,000
NET BENEFITS	-291,000
BENEFIT TO COST RATIO (B/C)	0.48

Table 4.6

SANTA CRUZ HARBOR SHOALING
GENERAL INVESTIGATION STUDY

ANNUAL BENEFIT TO COST COMPARISON
ALTERNATIVE 6: FIXED JET PUMPS

DESCRIPTION	COST
Project First Cost (incl 8% E&D, 7% S&A)	$ 1,840,000
Lands, Easements and Rights-of-way (Staging/Work Areas/Storage)	440,000
Interest During Construction (1/2 yr @ 8.5%)	78,000
TOTAL INVESTMENT COST	2,358,000
Capital Recovery Factor (CRF) (8-1/2% for 50 years)	(0.08646)
Annualized First Cost	204,000
Annual Operations & Maintenance	210,000
AVERAGE ANNUAL COST	414,000
AVERAGE ANNUAL BENEFIT	269,000
NET BENEFITS	-145,000
BENEFIT TO COST RATIO (B/C)	0.65

Table 4.7

SANTA CRUZ HARBOR SHOALING
GENERAL INVESTIGATION STUDY

ANNUAL BENEFIT TO COST COMPARISON
ALTERNATIVE 7: MOBILE JET PUMP

DESCRIPTION	COST
Project First Cost (incl 8% E&D, 7% S&A)	$ 1,725,000
Lands, Easements and Rights-of-way (incl Crane & Pipe Storage)	830,000
Interest During Construction (1/2 yr @ 8.5%)	73,000
TOTAL INVESTMENT COST	2,628,000
Capital Recovery Factor (CRF) (8-1/2% for 50 years)	(0.08646)
Annualized First Cost	227,000
Annual Operations & Maintenance	150,000
AVERAGE ANNUAL COST	377,000
AVERAGE ANNUAL BENEFIT	167,000
NET BENEFITS	-210,000
BENEFIT TO COST RATIO (B/C)	0.44

5.0 TECHNICAL CONSIDERATIONS

5.1 General

This chapter summarizes the design, economic and environmental considerations used in developing and evaluating the alternative plans.

5.2 Design Criteria Affecting Alternatives

5.2.1 Site Description and Geology

Santa Cruz Harbor opens into Monterey Bay, California, and occupies the former site of Woods Lagoon. The lagoon was a fresh water pond that extended approximately 4,500 feet inland from the ocean; the sediment filled portion was found to extend 1.5 miles inland. The lagoon was a drowned portion of a gully of a small stream called Arana Gulch; it was isolated from the ocean by a barrier beach and sand bar across its mouth. The outer 900 feet of the harbor entrance channel has a project depth of -20 feet mean lower low water (MLLW) and the inner 370 feet of the channel has a project depth of -15 feet MLLW. The channel is flanked on each side by rubblemound jetties. The east jetty is 850 feet in length and the west jetty is 1,125 feet in length. The harbor is surrounded on three sides by cliffs of a large marine wave-cut terrace. At the mouth of the former Woods Lagoon the cliffs on the west side are approximately 45 feet high and on the east side, approximately 20 feet in height.

The most recent sediments in the region are Holocene in age (less than 11,000 years old) and consist of loose sand forming the beaches and a thin blanket covering the bedrock bottom of the bay. Also, fine-grained sand, silt, clay, and organic mud were deposited in Woods Lagoon (U.S. Army C.O.E., 1960). Accumulated deposits of shoaled sand along the edges of the entrance channel have locally become compacted sufficiently to make them difficult to remove with a hydraulic dredge.

According to boring logs taken in the entrance channel in 1976, soft to firm clayey sediments exist at or just below -20 feet MLLW. However, recent dredging practice by the Santa Cruz Port District has been to overdredge to -30 feet ± MLLW in the vicinity of the angle point at the dogleg bend of the entrance channel. There have been no known reports of dredging clays.

For more information about site geology and the geotechnical issues associated with the primary project alternatives, see Appendix E (Geotechnical Study).

5.2.2 Tides and Tsunamis

Water levels at Santa Cruz Harbor are affected primarily by astronomical tides modified by variations in barometric pressure and wave set up and set down. Tsunamis can significantly alter water levels but these are rare at Santa Cruz.

Tides. Tides at Santa Cruz Harbor have a mean diurnal range of 5.3 feet and an extreme range of about 10.5 feet. The highest estimated tide (including any storm surge or wave set up) is +8.0 feet MLLW; the lowest estimated tide is -2.5 feet MLLW.

Tsunamis. Tsunamis are a class of long-period (8- to 100-minute) waves caused by seismic disturbances. Historically, there are few reported incidences of tsunamis affecting Monterey Bay. The 100-year tsunami "run-up" value determined for Santa Cruz Harbor by Garcia and Houston (1975) is 9.4 feet mean sea level datum or 12.3 feet MLLW. The statistical effect of astronomical tides on tsunami runup is incorporated in Garcia and Houston's estimate.

5.2.3 Wave Climate

Santa Cruz Harbor is effected by Northern Hemisphere swell, Southern Hemisphere swell, and seas generated by local winds. While Southern Hemisphere swells and local storms periodically generate moderate surf, Northern Hemisphere storms are by far the prevailing source of waves affecting Santa Cruz Harbor. These waves most frequently approach Monterey Bay from the northwest although waves produced by the largest storm events tend to arrive from southwest to west.

Because the harbor is sheltered by Point Santa Cruz to the west and by Point Cypress at the south end of Monterey Bay, waves arriving at the harbor entrance are often quite refracted. Most waves arriving at the site have periods between 10 and 20 seconds and approach in shallow water (30- to 40-foot depths, MLLW) from the southwest (between 200 and 230 degrees) with heights significantly reduced from their deep water values.

Deepwater significant wave heights can exceed 30 feet off Monterey Bay. The largest recorded significant wave height in deep water off Monterey Bay occurred 30 January 1990 with a value of just over 30 feet and associated period of 20 seconds. This 30 January 1990 reading is considered a 10- to 15-year event for Monterey Bay (Kendall and Cole, 1990). However, this deepwater "wave of record" was from a storm out of the northwest which, as a result of refraction, produced a significant wave height of less than five feet at the Corps of Engineers' gage located in 40 feet of water just offshore of the harbor.

In the shallow waters just offshore of the harbor entrance (-20 to -40 feet, MLLW), the largest recorded significant wave heights are in the 10- to 14-foot range whereas the typical recordings are in the 1- to 3-foot range.

Refraction, diffraction, and shoaling analyses have been used to model what happens to typical 10- and 17-second waves approaching the harbor from 215 degrees at the 40-foot depth contour. As the waves converge on the 10- and 15-foot contours surrounding the west jetty head, they are amplified as much as 50 percent (see Plates 5d and 5g).

When the waves encounter water depths roughly equal to their height, they break. The design wave heights established for the jetties in 1960 (21 feet for the west jetty and 14 feet for the east) were based on the water depths at that time. Subsequent shoaling of the seafloor in the vicinity of the jetties has most likely made the original design heights unattainable. Models cannot be used to demonstrate a clear change in wave conditions as a result of the shoaling which has taken place adjacent to the jetty heads (see for example, the wave height transformations shown in Plate 5c-Pre-Harbor vs. Plate 5d-Post-Harbor). It is evident, however, from observations in the field that much of the current navigation problem is a result of waves which initiate breaking on the shallower shoal area just west of the channel and continue to spill and break across a portion of the entrance.

Another wave climate problem at Santa Cruz Harbor is that of surge or long-period waves of basically unknown origin creating oscillations of up to 2.5 feet in height in the harbor basin. Most of the energy in the larger of these waves occurs in the two-to-five-minute period range.

The basin configuration (a long, essentially rectangular basin, closed at one end) causes long wave amplifications in the harbor. All of the proposed alternatives for this shoaling study will have a negligible effect on basin response (see Appendix B). A brief analysis of ways to reduce the surge problem at Santa Cruz Harbor is presented in Appendix B. These solutions generally involve limiting the long wave energy entering the harbor or modifying the boundary conditions within the harbor.

5.2.4 Littoral Environment and Dredging History

Santa Cruz Harbor is located within the Santa Cruz Littoral Cell. This cell extends as far north as San Francisco and terminates downcoast at the Monterey Submarine Canyon, near the center of Monterey Bay. Griggs and Best (1990) estimate that coastal streams supply about 75% of the total littoral sand input to the cell, bluff erosion contributes about 20%, and the remaining 5% is from gully erosion and sand dune deflation. The sand from these sources is moved through the cell by wave-induced longshore transport.

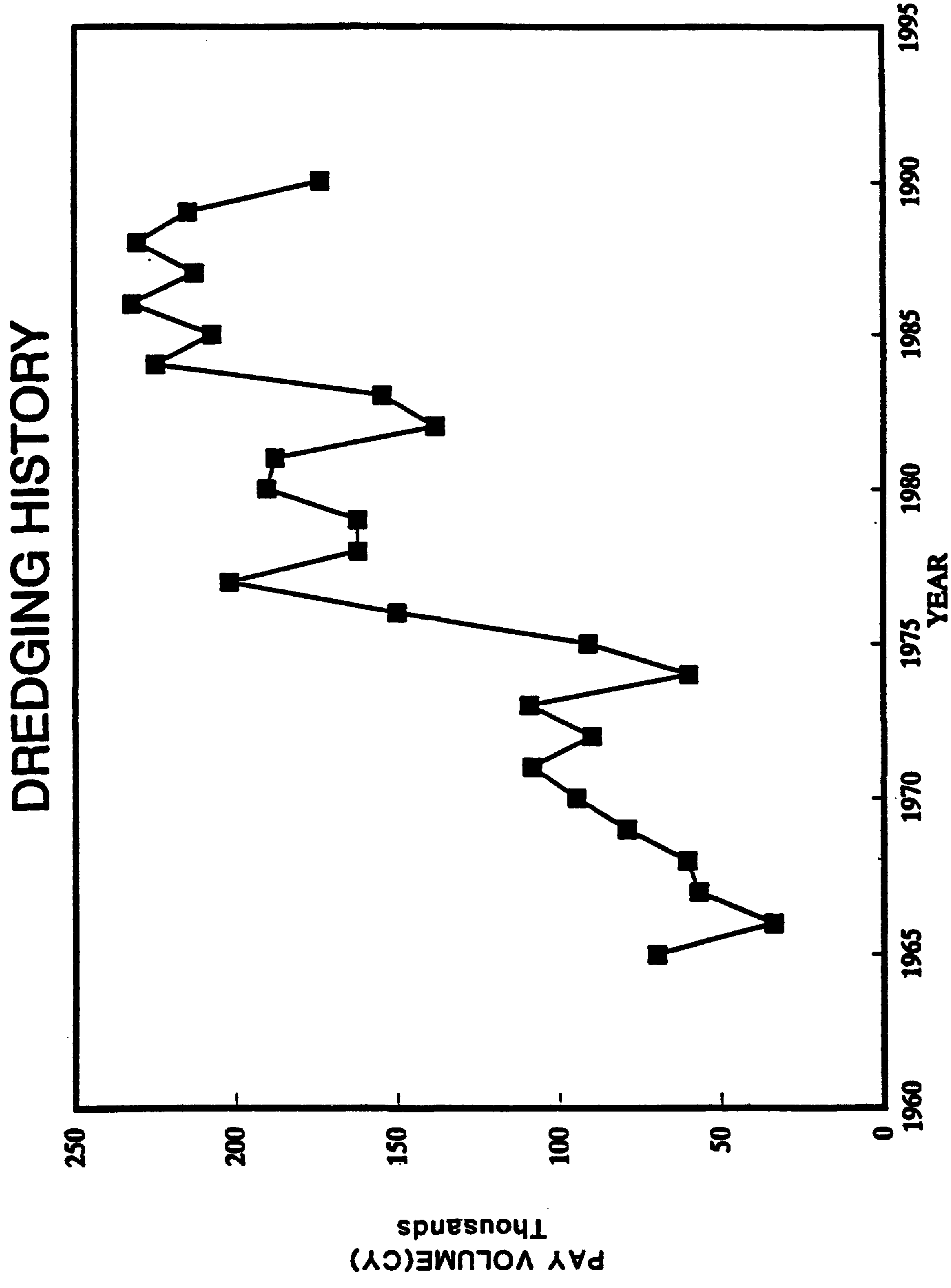
The beaches in the vicinity of Santa Cruz Harbor have well-sorted fine-grained sands with a median diameter of about 0.3mm. Samples from within the harbor suggest that the sands carried into the harbor are slightly finer than those on the adjacent beaches.

The seasonal change in wave energy causes a significant widening of the beaches during the summer and fall followed by the nearly complete stripping of sand from the beaches during winter. The presence of the jetties and significant west-to-east longshore transport, however, has produced a relatively stable fillet of impounded sand just upcoast of the west jetty.

Inman (1976) suggested that the shoaling processes near the harbor involve the removal and deposition of beach sand offshore by steep storm waves and the redistribution of the sand by longer-period swell moving the drift shoreward back onto the beach and into the channel.

The sediment budget analysis conducted for this study (see Figure 2.3 and Appendix E) suggests that between 35 and 60% of the net easterly longshore transport passing the west jetty (300,000 to 500,000 cubic yards (cys)) enters the harbor on an annual basis. These sands, of course, must be dredged out. Figure 5.1 traces the history of annual dredging volume in Santa Cruz Harbor from 1964 to 1991 showing a general trend of increasing yardage with time. (Note that the quantities plotted are pay yardages; for a discussion of the possible differences between pay yardage and actual volume see Appendix B.) Presently, dredging quantities average about 200,000 cubic yards per year. Some of the increase in dredging is attributed to more frequent dredging, which has kept the entrance open longer, thereby capturing more sand. Some of the increase, however, may also be due to the west fillet reaching its maximum extent sometime between the late 1970's and early 1980's. While the Port District has the impression that depths to the southwest of the harbor have continued to shallow, a review of shoreline positions and beach profiles suggests that the build-up on the west beach has ceased and the fillet's dimensions have stabilized (Appendix B). The upcoast accretion/impoundment due to the jetties appears to terminate at the San Lorenzo River mouth, about 0.6 mile west of the harbor. Except seasonally, impoundment upcoast has apparently ceased and the amount of sand crossing the harbor mouth should have reached a quasi-steady state. This would imply that the present maintenance problems and associated hazards should not worsen with time.

During storms (when most transport occurs and littoral drift becomes the primary harbor infilling mechanism) harbor infilling may be as high as 70 percent of the easterly longshore transport initially and taper off to zero as the capacity of the entrance is consumed. Corrected slope array data from 1978-82 have been used to estimate extreme easterly transport shoaling events (Table 5.1). These events typically last from two to four days. The tabulated values reflect the quantity of sand being transported in the event; the amount that enters the harbor is somewhat less as indicated above. The chance of equalling or exceeding various return period shoaling events for different periods of concern is summarized in Table 5.2. For example, the estimated 5-year easterly transport shoaling event (36,900 cys) has a 67% chance of being equaled or exceeded in a 5-year period. On a daily basis during the dredge season, the net easterly longshore transport is estimated to be less than 3,350 cys about 85% of the time; daily rates in the 20,000 to 23,500 cys range are only estimated to occur about 0.3% of the time. The estimated percent exceedance of daily net longshore transport quantities during the dredge season is summarized in Table 5.3.



DREDGING HISTORY

FIGURE 5.1

TABLE 5.1
SANTA CRUZ HARBOR
SHOALING STUDY

Extreme Shoaling Event Return Periods
Estimated From 1978-1982 Slope Array Data*

Return Period (years)	Easterly Transport Shoaling Event (cy)+
2	30,500
5	36,900
10	41,100
25	46,100
50	49,700
100	53,000

*Based on corrected 1978 - 1982 slope array data records (Castel el al, 1991)

+Transport values listed are reduced to 67% of those reported by Castel et al (1991) in order to scale these results such that the annual volume they reflect is nearer the middle of the range of estimates provided by other researchers (e.g. Griggs and Best, 1990), yet still within the confidence limits of Castel's data.

TABLE 5.2

SANTA CRUZ HARBOR SHOALING STUDY

PERCENT CHANCE FOR SHOALING EVENT EQUALING OR EXCEEDING RETURN PERIOD SHOAL EVENT

Return Period (Yr)	Period of Concern (Yr)					
	2	5	10	25	50	100
2	75	97	100	100	100	100
5	36	67	89	100	100	100
10	19	41	65	93	99	100
25	8	18	34	64	87	98
50	4	10	18	40	64	87
100	2	5	10	22	39	63

TABLE 5.3
SANTA CRUZ HARBOR
SHOALING STUDY

Percent Exceedance
of
Daily Net Easterly Longshore Transport
Quantities During Dredge Season *

Daily Net Easterly Longshore Transport(cy's)+	Total Observations	% of Dredge Season
0 - 3,350	658	85.6%
3,350 - 6,700	84	10.9%
6,700 - 10,050	20	2.6%
10,050 - 13,400	3	0.4%
13,400 - 16,750	1	0.1%
16,750 - 20,100	1	0.1%
20,100 - 23,450	2	0.3%
	769	100%

*Based on corrected 1978 - 1982 slope array data records (Castel et al, 1991) from November through May (7 months per year)

+Transport values listed are reduced to 67% of those reported by Castel et al (1991) in order to scale these results such that the annual volume they reflect is nearer the middle of the range of estimates provided by other researchers (e.g. Griggs and Best, 1990), yet still within the confidence limits of Castel's data.

5.3 Effectiveness of Primary Alternatives

The following subsections highlight the design features and discuss the effectiveness of each primary alternative. Additional geotechnical design detail is presented in Appendix E (Geotechnical Study); primary alternative cost estimates and associated real estate costs are contained in Appendices F and G, respectively.

5.3.1 No Action

As discussed in the "Statement of the Problem" (Section 3), safe navigation at Santa Cruz Harbor is presently limited in two ways: (1) shallowed conditions adjacent to (west of) the entrance channel initiate wave breaking which can carry into the channel; and (2) shoals in the entrance channel itself require frequent dredging and contribute to entrance wave breaking. These conditions are caused primarily by relatively high littoral transport and the harbor's small tidal prism and relative inability to naturally scour the jettied entance.

Under existing conditions or the "no action" alternative, the Port District battles these limiting conditions to the best of its abilities and in compliance with the terms of the 1986 Agreement by operating the dredge <u>Seabright</u> roughly 40 hours per week between November and May each year, moving an average annual quantity of about 200,000 cubic yards.

Since acquisition of the dredge <u>Seabright</u> in 1986, channel depths relative to Mean Lower Low Water (MLLW) have averaged less than 15 feet about 50 days per year (significantly less than the design depth of 20 feet) and less than 10 feet about five days per year. Table 5.4 summarizes channel depths reported by the Port District in their last five annual reports.

The design depth of 20 feet was established in the Project Document based on projections of deeper draft vessels using the harbor. While maximum vessel drafts are actually around 12 feet, the additional depth is still required because of surf hazards.

Even when the dredge keeps up with the incoming sand and the channel remains at design depth, larger waves will break seaward of the west jetty tip shoal area and continue to spill up to two-thirds of the way across the entance channel. This condition is believed to occur whenever entrance wave heights exceed three to four feet depending on shoal conditions, and may impact navigation up to two months per year. The Port District is presently documenting surf conditions at the entrance on a daily basis to help quantify this better. High demand for the harbor (over 50,000 outings per year) does suggest that this could be a serious economic problem.

The design width of the entrance channel is roughly 125 feet between the jetty heads. During shoaled conditions or when waves are breaking across a portion of the entrance, the usable width of

Table 5.4

SANTA CRUZ HARBOR SHOALING STUDY
HARBOR SHOALING STATISTICS

	AVG ENTRANCE DEPTH (FT, MLLW)	# OF DAYS	% TOT	CUM %
90-91 NOV 1- MAY 15	<10	0.00	0.00	0.00
	10-15	75.00	38.27	38.27
	>15	121.00	61.73	100.00
	TOT	196.00		
89-90 NOV 1- MAY 15	<10	0.00	0.00	0.00
	10-15	16.00	8.16	8.16
	>15	180.00	91.84	100.00
	TOT	196.00		
88-89 NOV 1- APRIL 30	<10	0.00	0.00	0.00
	10-15	12.00	6.63	6.63
	>15	169.00	93.37	100.00
	TOT	181.00		
87-88 OCT 1- APRIL 30	<10	13.00	6.10	6.10
	10-15	75.00	35.21	41.31
	15-20	105.00	49.30	90.61
	>20	20.00	9.39	100.00
	TOT	213.00		
	>15	125.00	58.69	
86-87 NOV 1- MAY 30	<10	10.00	4.33	4.33
	10-15	65.00	28.14	32.47
	15-20	136.00	58.87	91.34
	>20	20.00	8.66	100.00
	TOT	231.00		
	>15	156.00	67.53	
86-91 AVERAGES	<10	4.60	2.26	2.26
	10-15	48.60	23.89	26.16
	>15	150.20	73.84	100.00
	TOT	203.40		

SOURCE: Annual Reports 1987-1991, Santa Cruz Port District, Santa Cruz, CA

channel is reduced. Theoretically, this narrowing of the usable channel impacts the deeper draft vessels more than the shallow. According to EM 1165-2-1615 ("Hydraulic Design of Small Boat Harbors"), vessels with a draft of more than six feet require a channel width of 125 feet while a width of 75 feet is adequate for shallower draft vessels. According to Stan Salonius, who operated dredges at Santa Cruz for over a decade, when the channel is at design depth, wave breaking does not impact the east side of the channel and boats which need to get out or in can do so. The Port District, however, believes that the situation is unsafe and the many boaters who would otherwise be using the harbor, paying launch fees, etc., are not doing so during such conditions.

Table 5.5 provides a selective summary of the average channel dimensions through the shoaling section of the harbor during the dredging season for the different years and types of dredge operations historically used. The channel dimension "index," as defined in Table 5.5, has also been overlayed (Figure 5.2) on the dredging history of Figure 5.1 for each of the standard operating years reported in the table. This summary does suggest that an improvement was achieved during the first season of operation for the <u>Seabright</u> ("1986-87 Harbor-Owned Bypass") when an average channel dimension index value of 7.0 (125-foot width; 16 to 20-foot depth) was realized. A comparison of 1986-87 with the subsequent seasons listed in Table 5.4 suggests that the standard set in 1986-87 has been reasonably well maintained since. This is due, in part, to the Seabright and, in part, to a recent lack of extreme shoaling events. One explanation for the lack of extreme shoaling events is that, since dredge acquisition in November 1986, the weather has been relatively mild and the water levels have not been extreme such that adjacent beaches have experienced relatively few significant storm erosion events which could mobilize large amounts of sand into the harbor. This pattern may be changing, however; two-and-a-half months into the 1991-92 season the Port District had already dredged 110,000 cubic yards.

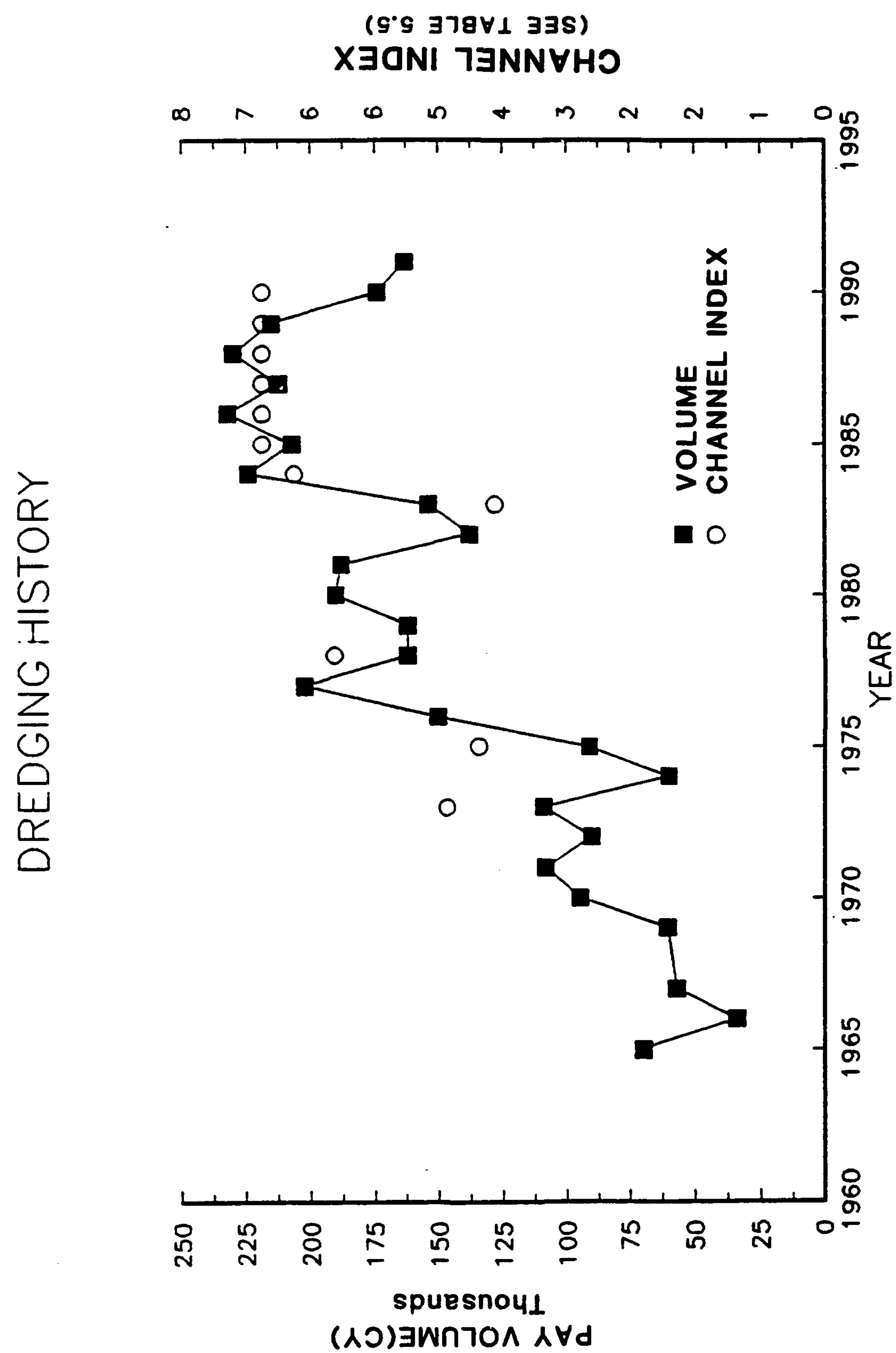
The Port District feels that up to 300,000 cubic yards per year of entrance sands can be managed by the dredge <u>Seabright</u>, as contrasted with the average of around 200,000 cubic yards per year presently removed from the entrance. The 300,000 yard annual capacity is based on increased efficiencies achieved when a large shoaling event overwhelms the harbor and the dredge operates in the lee of a large shoal.

Roughly 90 percent of the total yards removed each year are from the entrance. While in operation at the entrance, the dredge removes an average of just over 300 yards per hour. Because of pipeline work, etc., running time for the dredge averages 77 percent of the total crew time. Therefore, the effective rate over all hours invested is closer to 230 yards per hour. Note that the amount removed per hour of digging has averaged near 500 cubic yards. The operational average is lower because only about 60 percent of the dredge operation hours are spent actually digging as opposed to pump cleaning, etc.

TABLE 5.5
SANTA CRUZ HARBOR SHOALING STUDY
HISTORICAL DEPTH AVERAGE THROUGH SHOALING SECTION
NOV 1 - MAY 30 (7 MONTHS)

CHANNEL DIMENSIONS			1973-74 SINGLE-PHASE ANNUAL DREDGING MAR/APR		1975-76 SINGLE-PHASE IN MARCH/ APRIL		1976-77 EXPERIMENTAL BYPASS AND SINGLE-PHASE		1977-78 FIRST YEAR FOUR-PHASE 1977-84		1983-84 TWO-PHASE DREDGING FEB-APR		1985-86 TWO-PHASE DREDGING FEB-APR		1986-87 FIRST YEAR HARBOR-OWNED BYPASS	
INDEX VALUE	WIDTH-DEPTH		DAYS	PERCENTAGE OF TOTAL SEASON	DAYS	PERCENTAGE OF TOTAL SEASON	DAYS	PERCENTAGE OF TOTAL SEASON	DAYS	PERCENTAGE OF TOTAL SEASON	DAYS	PERCENTAGE OF TOTAL SEASON	DAYS	PERCENTAGE OF TOTAL SEASON	DAYS	PERCENTAGE OF TOTAL SEASON
1	0	0	0	0	27	12.8%	59	28.0%	0	0	0	0	0	0	0	0
2	<50'	<5'	72	34.1%	59	28.0%	52	24.6%	20	9.5%	92	43.6%	0	0	0	0
3	50'	6'-10'	10	4.8%	5	2.4%	13	6.2%	7	33.0%	28	13.3%	7	3.3%	0	0
4	50'	11'-15'	0	0	46	21.8%	21	10.0%	53	25.4%	0	0	0	0	0	0
	75'	6'-10'	0	0	0	0	0	0	0	0	0	0	0	0	10	4.7%
5	75'	11'-15'	61	28.9%	0	0	0	0	17	8.1%	14	6.6%	14	6.6%	17	3.3%
6	75'	16'-20'	8	3.8%	9	4.3%	0	0	64	30.3%	31	14.7%	0	0	0	0
	125'	11'-15'	0	0	0	0	0	0	0	0	0	0	78	40.0%	48	22.6%
7	125'	16'-20'	27	12.9%	22	10.4%	10	9.7%	35	16.6%	31	14.7%	98	46.4%	136	64.6%
8	125'	20'+	33	15.6%	45	21.3%	15	7.1%	15	7.1%	15	7.1%	15	7.1%	20	9.4%
AVERAGE INDEX VALUE:			4.7		4.3		2.6		6.1		4.1		6.6		7.0	

Source: Santa Cruz Port District, First Annual Report, Santa Cruz Harbor Sand Bypass System, 1986-87 Dredging Year, October 1987.



DREDGING HISTORY w/CHANNEL INDEX

FIGURE 5.2

Additional use of the present system, with the objective of creating storage areas capable of trapping some of the sand that would otherwise impact entrance safety, represents Alternative 4 and is discussed in Section 5.3.4. On the other hand, simply dredging more hours (i.e. longer shifts, including overtime, if necessary) after a large storm event has shoaled in the harbor is really a matter of using the present system more intensively. This could substantially reduce the recovery time following a shoaling event. The dredge, however, cannot proceed seaward of the more protected area in the lee of the shoal until entrance waves heights are less than three feet. Therefore, "overtime dredging" can only proceed so fast. Entrance conditions may remain too rough for the dredge for several days following the storm that caused the shoaling event. Nonetheless, a typical 30,000 cubic yard shoal, which at optimal efficiencies presently requires at least two weeks to clear, could be cleared in as little as one week, weather permitting, if double shifts are run, or even less time if the dredge is run 24 hours per day.

While 24-hour-per-day episodic dredging was the procedure used by contractors during the Corps funded days of phased dredging (which required that equipment remain at Santa Cruz Harbor between December and April), the Port District concluded that maintaining a 24-hour-per-day crew on stand-by through the winter was "very expensive and not practical" in summarizing its operational concept in its first annual report (Santa Cruz Port District, October 1987). The following is an excerpt from that report:

"a) The Port's objective is to keep the harbor operational as close to 100% of the time as financially possible and as safety concerns allow;

b) Although shoaling in the harbor entrance has some gross predictability by season, it has no predictability on a daily basis;

c) The harbor entrance has very little storage capacity; i.e. it can shoal up overnight in an intense storm which can deposit sand at upward of 15,000 cubic yards [per day]; dredge crews need to be available immediately;

d) The Port District would more than triple its management problem by trying to keep three crews ready to perform 24-hour-per-day dredging;

e) The Port District is remote from dredging labor pools and would have a difficult time manning sporadic or continuous, 24-hour-per-day operations.

It was with these parameters in mind that the Port District technical committee specified a dredge which would have a peak capacity in excess of 1,000 cubic yards per hour on a

short line. This would equilibrate to 250 cubic yards per hour on an overall average basis. 2,500 [sic] yards per ten-hour shift stretched from November to April, in 40- to 50-hour weeks, would give the Port operation over 200,000 cubic yards per year. This was far in excess of the average at Santa Cruz. The known drawback to the 40- to 50-hour week single-crew concept was that even at 5,000 yards per day, which is well within a dredge's capability, it could take four to five days to create a usable channel. Still, the Port District decided to take this option because:

a) By having the crew work continuously (four to five days at 10 hrs/day) over the winter, they would keep a deep channel most of the time, thereby creating excess storage capacity for future storms;

b) Massive sand movement by storm activity is unpredictable and relatively few in number and the full-time, single-crew shift crew would always be immediately available;

c) Four to five days of digging-out time is an acceptable timeframe; shorter closure time could only be accomplished by 24-hour-per-day crew on standby through the winter; this is very expensive and not practical.

Thus, the Port District decided it would hire one complete crew and run four or five, ten-hour days per week from November 1 through April and into May, if necessary. The loss of time, due to daily start-up and shutdown was a known and was an acceptable loss. The 250 yards per hour of total operating hours (40 or 50 hours per week) was acceptable."

Five years later, some of the Port District statements can be updated. The overall average rate of dredging has been 230 yards per hour (not quite 250 yards per hour), operating hours have been 40 hours per week and have typically continued into May. Also, while 200,000 cubic yards per year was in excess of the previous (prior to dredge acquisition) average for Santa Cruz, it is roughly the average value since dredge acquisition. The higher dredge quantities are believed to have resulted in part from the fact that earlier yardages were pay quantities based on pre- and post-dredge surveys which did not account for the extra yards moved to keep up with continued infilling during dredging. In addition, more continuous dredging has led to less natural bypassing of sand during shoaled entrance conditions and, therefore, has required more sand to be bypassed by the new dredge. And, as a final update to the Port District's 1987 statements, the anticipated creation of a "usable channel" within four to five days has proven to be only true to the extent that "usable" does not necessarily imply that the entire shoal is removed or that the resulting channel is safe.

5.3.2 East Jetty Sealing

The east jetty has never been sealed and is highly porous. The original core elevation is only -2 feet MLLW. As much as 6,000 yards (an upper limit suggested by Moffatt & Nichol, 1992) may leak through the jetty annually. The jetty is also frequently walked upon and the several "manhole-sized" openings along the crest represent a pedestrian hazard.

The prevailing longshore sand transport near the harbor is to the east. It is anticipated that the infrequent flows to the west would be of insufficient duration to cause east beach sand kept out of the harbor by jetty sealing to accumulate and enter the harbor via an east jetty tip shoal. Sealing the east jetty with a concrete grout could keep out over 80% of the sand now leaking through the structure and provide a safer walking surface on the crest. This could represent an annual benefit of 5,000 yards in reduced dredging requirements, but would produce negligible improvements to navigation.

The proposed plan (Plates 2a-2d) is primarily face sealing (350 feet) with only the outer 100 feet receiving a centerline seal. Sealing the face of the jetty is more effective and less costly than a drilled centerline seal. Face sealing, however, also introduces more environmental concerns, including reflected waves possibly scouring the east beach. Wave run up, overtopping, jetty pore pressures, and local scour are all possibly affected by sealing. Many of these effects may be minimal, however, as most waves propogate in a direction which parallels the jetty axis.

5.3.3 Pipeline Extension

The intent of this alternative (Plate 3) is to reduce the amount of westerly moving sand which reenters the harbor. Based on measurements with a slope array located southwest of the harbor in just over 20 feet of water, up to 60,000 yards per year of sand is potentially transported in a westerly direction. Moffatt & Nichol (1992) estimate that annual transport into the harbor from around the east jetty ranges from 10,000 to 40,000 yards. Most of the westerly flows or "reversals" suggested by the gage occur during the summer when the dredge is not in operation. This type of flow pattern is reportedly observed by swimmers in the area as well. Reversals, however, may be more frequent in winter time than the gage suggests. Calculations based on hindcast wave data indicate about half of the westward transport occurs during the winter due to southeast wind waves (Moffatt & Nichol, 1978). Another factor contributing to localized reversals on the east beach is the presence of a counterclockwise return gyre in the lee (east) of the east jetty which feeds a rip current along the jetty and which, along with refraction/diffraction, tends to redirect waves more to the west as they wrap around the jetty head. A possible upper limit of 20,000 cubic yards of sand may be moved towards the harbor from just east of the east jetty during the dredging season. This

upper limit is probably not unrealistic, especially when dredged sand is being deposited in this area since this sand is more mobile than the surrounding, more consolidated sand.

The discharge pipe presently terminates on the beach no more than 600 feet from the east jetty. The dredge, however, has the horsepower to pump sand much further. Extending the discharge pipe east over 1,000 feet from the jetty to near the first house along the east beach (the reveted "Pink House Point" is located approximately 1,250 feet from the jetty) should place the material out of the wave shadow of the east jetty and, thereby, reduce the likelihood of it being carried back to the harbor.

The reverse flows indicated by the gage tend to last on the order of two to four days. During this time, sand deposited on the east beach may travel on the order of 1,000 feet or less, i.e. if the discharge point is moved over 1,000 feet to the east of the east jetty, discharged sands should not reach the entrance before the predominant easterly-moving longshore transport resumes.

Not all sand, however, can be placed over 1,000 feet east of the jetties. Sand is periodically needed closer to the jetties for nourishment of the beach which fronts a row of commercial establishments there. If, following initial placement of roughly 30,000 to 40,000 yards of annual nourishment sand on this stretch of beach just east of the east jetty, the balance of the sand were placed further east near Pink House Point, some amount of sand transport back into the harbor should be avoided.

Nourishment requirements will vary significantly from year to year (from none at all to 60,000 yards). The Port District's primary dredge leverman for 17 years only recalled one dredge season where disposal was required immediately adjacent to the east jetty for nourishment purposes. Typically, the nourishment of the beach in front of the commercial development could commence several hundred feet east of the jetty. By using the coarser sands available near the higher energy entrance and tip shoals for this nourishment, the nourished beach should remain stable longer and, as a result, contribute less sand to the harbor entrance.

Although it is impossible to predict with any certainty, having the majority of the sand placed over 1,000 feet from the entrance should make a reduction in harbor dredging on the order of 10,000 yards possible. Navigation improvements are presumed to be negligible.

The most economic way to implement this alternative is to extend the pipe easterly over the course of the dredging season in increments laying each new section only after the beach has become sufficiently wide to allow pipe placement on high ground. The pipe would, of course, have a final segment which runs shore normal and terminates at the high-tide wave-runup line.

Presently, the maximum length of 16-inch ID High-Density Polyethylene (HDPE) pipe used on the beach is 700 feet. This section is connected to the 300-foot buried section of pipe which follows the back beach immediately downcoast of the east jetty (Plate 3). To reach "Pink House Point" via the back beach, approximately 850 feet of additional pipe are required.

In addition to acquiring the pipe, an additional hour may be required to mobilize and demobilize the additional pipe each day (all pipe must be stored well back of the high-tide line each evening). Daily mobilization will require an extra hour (at time and a half) from the mate and the deck hand. Assuming that 70 percent of the nominally 100-"business"-day dredge season requires this operation, 70 such days should be accounted for in the operational costs for this alternative. A minimal increase in fuel costs required to pump sand further would also be incurred.

5.3.4 Channel Sand Trap

One way to increase Santa Cruz Harbor's ability to handle large influxes of sand is to dredge out additional sand storage areas or sand traps. Three regions have been proposed for this: (1) on the beach west of the west jetty; (2) directly offshore of the west jetty dogleg; and (3) along the entrance channel. Of these, only overdredging in the existing channel can be safely accomplished on a regular basis by the existing floating dredge plant.

Trap Capacity. The proposed trap would run roughly between channel stations 16+50 and 19+50 and extend beyond the existing channel width as shown in Plate 4b. Given clay layers, jetty foundations, dredging experience, etc., a maximum depth of 40 feet below MLLW, as shown, is possibly attainable in the short term. Presently, however, 25- to 30-foot depths (as measured below MLLW) are frequently dredged during the normal operation of the Seabright only to produce an average depth throughout the year between 16 and 20 feet, say 18 feet (Plate 4a). Therefore, for storage purposes, the average section that can be anticipated throughout the year, given continuous channel slope adjustments and infilling, should be reduced to perhaps a 30-foot maximum depth (Plate 4c).

Storage capacities have been estimated for the various channel conditions (-18 feet typical, -30 feet proposed, and -40 feet maximum) under two different "shoaling event" scenarios.

A totally closed harbor condition is assumed to be represented by a shoal elevation of -2 feet MLLW (Plate 4d), i.e. a depth at which even 6-foot draft vessels cannot pass at anytime other than during the highest tide and flat calm conditions.

The threshold "shoaling event" for hazardous conditions is assumed to be represented by channel depths averaging 15 feet below MLLW (Plate 4e). Under these conditions, the larger (12-foot draft vessels) cannot pass on extreme low tides unless flat, calm

conditions exist. Flat, calm conditions rarely exist and shallower draft vessels are also affected by entrance breakers which initiate on the shallower shoal area just west of the channel and continue to spill over a portion of the entrance channel. When the channel shoals to around 15 feet, it is logical to assume that the tip shoal area has shallowed to between 5 and 10 feet as it "feeds" the channel. Therefore, hazardous conditions are consider probable under the -15-foot shoaling scenario.

To fill the harbor to a closed condition requires approximately 34,000, 48,000, and 74,000 cys for pre-shoaling event channel depths of 18 feet typical, 30 feet proposed, and 40 feet maximum, respectively. To fill the harbor in to a hazardous condition requires approximately 14,000, 28,000, and 53,000 cys for pre-shoaling event channel depths of 18, 30, and 40 feet, respectively.

Trap Benefits. For a deeper channel (sand trap), the efficiency of the harbor at trapping sand travelling alongshore is sure to increase. For determining the benefits of trap creation, easterly littoral drift will be treated as the primary infilling mechanism during storms and the trapping efficiency during storms will be assumed to range from 60% for the present dredge practice to 80% for the more aggressive dredging practice proposed for trap creation. On an annual basis, 60% infilling would be an absolute maximum for the present dredging practice. It has been assumed here, however, in order to be conservative when addressing extreme events and because other contributions to harbor shoaling are being neglected in this analysis. By taking the estimated trap capacities and dividing by the appropriate trapping efficiency we can identify the magnitude of the easterly transport shoaling event required to consume that capacity. Using Table 5.1, we can assign an approximate return period to that event. Table 5.6 summarizes the projected "level of protection" that the different traps would provide.

The level of protection the traps provide is expressed as a return period for trap filling. The chance of equalling or exceeding various return period events for different periods of concern can be estimated using Table 5.2. For example, in a five-year period, the percent chance of seeing the harbor shoal to -15 feet drops to about 67% for the -30 foot proposed channel trap from 100% for the typical -18 foot channel condition. Under either practice, however, this analysis suggests that total closure should be infrequent.

Another way to quantify possible trap benefits is to examine the percentage of the dredge season during which the daily net easterly transport (interpolating off Table 5.3) is of such a magnitude that closure or hazardous conditions are imminent for the different trap capacities.

TABLE 5.6
SANTA CRUZ HARBOR SHOALING STUDY
Projected
Level of Protection Provided
Against Shoaling

Pre-Shoal	Total Trap Capacity (cys)		Return Period for Trap Filling (years)	
Channel Condition	(-2 ft Shoal)	(-15 ft Shoal)	(-2 ft Shoal)	(-15 ft Shoal)
-18 ft MLLW	34,000	14,000	100	<1*
-30 ft MLLW	48,000	28,000	>100	5
-40 ft MLLW+	74,000+	53,000+	>>100+	100+

*Note that the -15-foot shoal over a -18-foot pre-shoal channel (i.e. 14,000 cys) is better described as a relatively common condition, not an extreme event.

+Note that the -40-foot pre-shoal channel cannot be realistically maintained between shoaling events. Therefore, the capacities and levels of protection it provides must be viewed only as ideal upper limits.

Assumptions made for this analysis will again include that easterly littoral drift is the primary infilling mechanism during storms and that trapping efficiencies will range from 60 to 80% depending on how large of an in-channel trap is used. It will be further assumed that if the daily net easterly transport entering the harbor exceeds 33% of that required to fill the trap, then that transport is part of a typical two- to four-day event made up of other above threshold daily quantities which will fill the trap. The final assumption is that the trap is maintained between events, but not during events. In other words, as soon as an event concludes, the dredge immediately restores some of the trap capacity and reestablishes its full capacity prior to the next event.

The above mentioned assumptions can be applied to estimate the probable percentage of the dredge season that the different traps could be filled (Table 5.7). Because of the assumptions made, estimated percentages may be low (optimistic) to the extent that successive events can occur without an opportunity to regain trap capacity between them.

If we were to assume that entrance hazards, wave breaking, and delays occur whenever the entrance shoals to -15 feet MLLW or shallower (and never when the harbor is deeper), then this analysis suggests that the percent of the dredge season that the harbor experiences such inconveniences would be reduced from 26% with the existing practice to 0.4% with the maintenance of a -30-foot channel/sand trap. In other words, the entrance problems would be virtually eliminated. This is probably an appropriate assumption for the initial benefit analysis.

Disclaimer On Entrance Waves. The benefit analysis assumes that keeping the entrance below -15 feet MLLW would eliminate entrance hazards. While it should provide some significant improvement, entrance hazards would not be altogether eliminated especially considering the narrowness of the entrance. Without carrying out a massive deepening effort seaward of the jetty heads, Santa Cruz Harbor will still be periodically subjected to waves which, having begun to break near the west jetty head, continue to spill after encountering the deeper water over the channel and sand trap. This process is not easy to model numerically.

What can be better described with models is the response of a typical unbroken wave encountering the deepened entrance. As the wave propagates into the deepened area it loses height and gains speed. This will tend to bend the wave (refraction) as the portion of the crest over the deeper center travels faster than the portion near the shallower sides. If the deeper area is extensive enough to cause the wave crest to bend to where it has essentially aligned itself with the lee side perimeter of the deepened area, then the energy of the wave is significantly redirected to the sides.

TABLE 5.7
SANTA CRUZ HARBOR SHOALING STUDY
Projected Percent of Dredge Season
With Shoaled Conditions

Pre-Shoal Channel Condition	Approx Single-Day Threshold "Capacity" (cys) (-2 ft Shoal)	Approx Single-Day Threshold "Capacity" (cys) (-15 ft Shoal)	Percent of Dredge Season Trap should Fill (-2 ft Shoal)	Percent of Dredge Season Trap should Fill (-15 ft Shoal)
-18 ft MLLW	17,000	1,750*	<0.1%	26.0%*
-30 ft MLLW	24,000	14,000	<0.1%	0.4%
-40 ft MLLW+	37,000+	27,000+	<<0.1%+	0.1%+

*Note that the -15-foot shoal over a -18-foot pre-shoal channel is better described as a relatively common condition which can develop over a longer window of activity, i.e. slightly rough conditions can exist for on the order of a week which keep the dredge from regaining the channel capacity. It is not well described by a peak event with an average duration of three days. Therefore, to better match the observed average percent of the dredge season that depths average 15 feet or less (26%; Table 5.4), an "event" duration of about eight days was used to come up with the approximate single-day threshold "capacity".

+Note that the -40-foot pre-shoal channel cannot be realistically maintained between events. Therefore, the capacities and percentages shown are unrealistic extremes.

However, if the "hole" is not broad enough relative to the wavelength, then much of the initial reduction in wave height which occurred while propagating into the deeper water is recovered when the lee edge of the "hole" is encountered, thereby passing the energy further into the harbor and less onto the interior slopes of the jetties. At least for shorter period waves, the proposed over-deepening is presumed to effectively redirect the waves.

The preceding discussion focussed on wave refraction; wave diffraction is also at work in a jettied entrance causing wave heights to decay along the channel center as their energy is absorbed into the interior slopes of the jetties (Melo and Guza, 1991). It is hoped that such a reduction would minimize the impact of entrance overdredging on wave heights further back in the harbor.

Trap Maintenance. Maintaining the proposed trap will require an additional amount of sand to be moved each year. The proposed alternative will only involve the dredging of sand; it has been assumed that the clay layer will be avoided. (Note that borings do indicate clay beneath the jetties and the slope analyses done for this excavation do consider clay.)

The historic pattern of generally dredging more yards in order to realize an increasing average channel depth and width can potentially be used to extrapolate the amount of additional dredging required to maintain a -30-foot channel. The channel and dredging history in Figure 5.2 can be checked for any suggested pattern. The data are spotty and do not take into account the change in method of payment introduced in 1986-87 (which is partly responsible for the increase in reported yards) nor the variations in weather from year to year. Nonetheless, the record may be used to suggest that in removing approximately 100,000 more yards, the harbor conditions went from an index of perhaps 4.5 (probably about 75 feet wide and 8- to 12-feet deep) to about 7.0 (125 feet wide and 16- to 20-feet deep). This, in turn, can be used to suggest that at least 100,000 cys and perhaps as much as 150,000 cys of additional sand may have to be removed to consistently achieve the -30-foot depth over the trap dimensions. In other words, total annual dredging could be in the 300,000- to 350,000-cys range.

As an absolute minimum, the additional yards required to maintain the -30-foot condition would be the amount required over a single dredge cycle to dig down to -40 feet (recognizing that, given continuous channel slope adjustments and infilling, this will soon become the -30-foot condition proposed). This quantity is about 40,000 extra cubic yards. In other words, total annual dredging should be at least 240,000 cys.

As an absolute maximum, the ratio of storage volumes below a -15-foot shoal (with the proposed -30-foot channel versus to a typical -18-foot channel) can be used to scale up the dredging quantity to be anticipated in maintaining the -30-foot condition. The -30-foot channel has a 28,000-cy capacity; the -18-foot channel

has a 14,000-cy capacity, i.e. the -30-foot channel has twice the storage below a -15-foot shoal. From this it is possible to suggest that up to twice the dredging would be required annually, i.e. 400,000 cys. Since this is less than the maximum estimate of net longshore transport near the harbor, it is not an impossible figure. Furthermore, if we integrate the daily transport quantities in Table 5.3 using the previously suggested conservative (short-term) infill rate of 80%, the result is also 400,000 cys per year.

The sediment budget can also be examined for estimates of the increased dredging requirement associated with maintaining the -30-foot channel. The present dredging quantity (approx 200,000 cys) is presumed to be composed of about 30,000 cys from seasonal influxes, aeolian transport, and leakage through the jetties plus either about 35% of the maximum net longshore transport (500,000 cys) or about 60% of the minimum net longshore transport (300,000 cys) for the balance (see Figure 2.3). For the deeper entrance, it is possible on an annual basis to see perhaps 60% (the maximum infill rate for longshore transport) of 500,000 cys (the upper limit estimate of net longshore transport) entering the harbor, i.e. 300,000 cys. Assuming that the total input from other sources remains relatively constant at 30,000 cys, the maximum dredging requirement suggested from the sediment budget would be around 330,000 cys. This figure is near the center of the range suggested by the previous three methods (240,000 to 400,000 cys) and quite close to the 300,000 to 350,000-cy estimate extrapolated from the historic dredging patterns; therefore, 330,000 cys will be used as the best estimate for annual dredging requirements with the deeper entrance.

For the initial analysis, it can be assumed that an additional 130,000 cys is removed per year. This will require at least a 50% increase in operating hours from the dredge. As discussed in the section on existing conditions, additional dredge operation is limited by weather, overtime pay, etc. Such increased use could also result in reduction in the life expectancy of the dredge.

5.3.5 Offshore Sand Trap

The concept behind this alternative is to use a larger, more seaworthy dredge (clam shell or hopper) to increase water depths over an extensive area off of the harbor entrance. The preliminary dimensions of the excavation and disposal site are shown in Plates 5a and 5b, respectively. The deeper water created by the trap is intended to reduce breaking surf as well as requirements on the Seabright. The operation that is still required of the Seabright is presumed to be mostly limited to the relative calm of the channel and not beyond the jetties.

The offshore trap would be excavated in the fall and represent a significant modification to adjacent bathymetry initially. As the winter season progressed, the trap would fill and its effect on the harbor would be less pronounced.

Even with the trap at its full dimensions, it is difficult to model the exact improvement that it would provide. Modeling of wave transformations (refraction, diffraction, and shoaling) to the jettied entrance reveal no clear or patterned differences between the results for pre-harbor, post-harbor, and offshore sand trap conditions (see Plates 5c through 5h). The Corps' model RCPWAVE was used which relies on the mild slope assumption (which was likely violated by the input bathymetry). Test cases examined the transformation of typical 10- and 17-second waves approaching the harbor from 215 degrees at the 40-foot depth contour. Field observations, of course, do suggest that waves which are not necessarily large enough to break in the channel still do so because they have been tripped by shallow conditions adjacent to the channel. A general deepening of the surrounding area could improve this situation. For the initial benefit analysis, it is assumed that wave breaking is sufficiently reduced by the trap so that all the present navigation impacts can be offset. It is further assumed that the reduction in sand entering the harbor each year is on the order of half the 200,000 cubic yards removed from this area off the entrance, thereby reducing Seabright operation requirements by as much as 100,000 cubic yards.

The proposed 24-hour-per-day contract dredging would be able to create the trap in three to four weeks time. The larger dredge is limited as to how close it can get to the shore. Cables associated with wave gages, etc. in the area must also be avoided. The trap plan presumes the dredge cannot go landward of the 15-foot MLLW depth contour. It is recognized, of course, that the operator may be able to get further towards shore on higher tides and that in excavating to -25 feet MLLW, additional material from the adjacent shallower areas will slough into the excavated area, increasing the total dredge quantity and possibly the entrance improvements as well. The optimal size of the offshore trap would most likely be established through trial and error.

Disposal of the dredged sand has been assumed to be between the 15- and 20-foot MLLW depth contours such that the sand will be close enough to shore to keep the sand in the downcoast littoral system. However, if nearshore disposal is not allowed because of the Monterey Bay National Marine Sanctuary (see Section 5.5), then the sand may have to be pumped to the beach.

5.3.6 Fixed Jet Pumps

This system is intended to be an all-weather supplement to the existing dredge system, capable of maintaining the harbor at times when weather conditions are unfavorable or unsafe for operating the floating dredge. The primary benefits would come from the elimination of hazardous depths within the channel (safer navigation) and from reduced requirements on the existing floating dredge.

The simplest form of a jet pump or eductor system has been assumed for this initial analysis. Modifications to this basic concept, such as the "zipper" fixed pipeline-type system in use at Rosarito, Baja California or incorporation of fluidizers, could be investigated if any further study were merited. The system proposed would be similar to an experimental sand-bypassing plant operated in the late 1970's at Santa Cruz and would use eductors (Plate 5a) located in the entrance channel (Plate 5b). The experimental system was only capable of bypassing about 100 cys per hour; the proposed system would incorporate 8-inch jet pumps with 16-inch lines and be capable of about 500 cys per hour (1,000 cys per hour at absolute peak efficiencies). This increased capability is necessary to help ensure that the system can continue to operate during times of high shoaling. In the late 1970's, the harbor shoaled to the point where the water-intake pipe, which supplied the experimental system and was located near the back of the harbor entrance, became covered with sand and clogged, reducing production rates substantially.

The experimental plant experience also raised an interesting hypothesis regarding eductors located seaward (southwest) of the channel near the tip shoal. Shoaling histories with and without the bypass plant did not reveal significant differences in the shoaling patterns or rates. One of the explanations given for this was that much of the material that was pumped would have naturally bypassed the entrance had the system not been operated. One such "tip shoal" educator is shown as an optional installation in Plate 5b primarily for the possible benefit of reduced wave breaking by forming a crater where the tip shoal usually forms off the west jetty.

The proposed system would include eductor mounts or stop structures similar to those developed for Oceanside Harbor (Plate 5c) to limit excavation depth and would include the principal components outlined in Plate 5d. The 800 horsepower (hp) booster slurry pump indicated is assumed adequate for the present disposal practice on Twin Lakes Beach east of the jetty, however, this may need to be upgraded to 1,000 hp in order to reach Pink House Point under the extended discharge pipe alternative.

Jet pumps are self-metering devices requiring little operator intervention as they have no moving parts outside of the pump house. However, kelp and other debris may inhibit the entrainment of the sand/water slurry into the mixing chamber. While kelp and other debris problems were not highlighted in the reports found on the experimental jet-pump system of the late 1970's, they should not be overlooked. A mechanical chopper had to be installed on the suction head of the Seabright to slice up debris and kelp because their presence was often requiring over 100 pump cleanings in a 10-hour shift.

To alleviate clogging problems associated with kelp and debris, a pair of high pressure "clear water" nozzles (not shown on the plates) is presumed to be a part of the proposed design. These nozzles will be mounted around the mixing chamber entrance to act as water knives slicing up kelp wads, etc. With a 5/8-inch diameter opening producing 170-foot-per-second velocities, these nozzles have been successful for years at keeping kelp and debris out of the suction ports on the fixed dredge system in use at Rosarito, Baja California. Even with these nozzles in place, the operation must still be presumed to require periodic backflushing, eductor clearing with grapples deployed from a work boat, and even occasional raising of the educator - using a work boat - from its mount (buoyancy bottles, etc. would be used to facilitate this).

Jet Pump Benefits. The proposed system should be capable of moving at least 150,000 cys per year. The deeper craters created by the pumps should create a reduction in entrance breaking conditions similar to that suggested for the entrance sand trap. The jet pumps, presumed here to be more "all weather" than the floating dredge, should be able to maintain an overdeep entrance more consistently than the proposed floating-dredge maintained trap. The size of the craters, however, is such that the longer period waves entering the harbor are less likely to be affected by them (see discussion of "hole" size versus entrance waves in the Channel Sand Trap section). Davis (1992) demonstrated with a steady state spectral wave model that a single crater 50 feet in diameter and 17 feet deeper at its center than the surrounding approximately uniform 30-foot depths will tend to cause a typical 17-second wave to diverge and lose height only slightly before quickly recovering much of its initial height and heading once the back edge of the crater is encountered. The sequence of two to three adjacent craters shown in Plate 5b, however, was not modeled and may reduce entrance breaking conditions somewhat. For the initial benefit analysis, this alternative is credited with offsetting all the present navigation impacts.

In addition to navigation benefits, the fixed jet-pump sand bypass system will reduce the use of the existing floating dredge. Of the 150,000 cys per year anticipated to be moved by this system, as much as 50,000 cys must be viewed as sand that otherwise would have bypassed the entrance were this more

aggressive dredging practice not in effect. The same overdredging logic presented in the channel sand trap discussion has been used here. This implies a net dredge-use "savings" of about 100,000 cys.

5.3.7 Mobile Jet Pump

This alternative is illustrated in Plate 6a and is based on the sand bypass plant at Indian River Inlet, Delaware (Clausner et al, 1991) shown in operation in Plates 6b and 6c. A crane-mounted jet pump would be used to mine the sand on the west beach and create a storage area for sand traveling eastward, potentially keeping it from the entrance channel. While this is not as directly beneficial to the channel as removing sand directly from the entrance, the jet pump does operate more efficiently on the beach than in the channel and may draw down the adjacent beach enough to reduce wave breaking adjacent to the channel. Based on this, the initial benefit analysis will assume that roughly half of the present navigation impacts could be offset by implementing this alternative. There is no way to determine exactly how much of the storage created by mining the west beach will be used for sand that otherwise would have ended up in the harbor, but it is assumed for the initial analysis that at least half of the mined quantity (50,000 cys) would be kept from the entrance, thereby, reducing the annual operation requirements of the Seabright.

To take advantage of the Port District's existing crane, the proposed system is scaled down somewhat from the 8-inch jet pump and 135-ton crawler crane in use at Indian River. The proposed system will use a 6-inch jet pump deployed from the Port District's 70-ton mobile crane operating on steel mats placed on the beach. Sand mined from the beach west of the west jetty would be pumped to the east beach. The crane would be used to place the jet pump in approved areas that are well suited for mining. The jet pump would form craters as it buries itself (Plate 6c). When mining was complete, or if the jet pump became blocked, the crane would lift the jet pump from the crater and begin the process again at a new position.

5.4 Economic Analysis

The economic benefits for any alternative which would reduce the amount of sand reaching the harbor or provide for additional dredging in or near Santa Cruz Harbor are two-part: (1) the tangible benefits associated with improving the entrance conditions so that additional navigation benefits will be realized primarily over a period including December and January in which the shoaling is most severe, and (2) a partial substitution benefit for achieving improved entrance conditions with an alternative means so that some of the dredging performed by the Santa Cruz Harbor dredge Seabright is offset. From the Corps of Engineers (Federal) perspective, the primary benefits will be associated with providing additional boating-related opportunities through increased dredging; however, the additional dredging beyond this requirement will offset existing dredging costs and are considered to be NED benefits also.

A Santa Cruz Port District questionnaire (the "survey"), developed to identify the navigation related problems of the existing harbor was distributed by the Santa Cruz Port District (SCPD) to approximately 200 of their boaters. These questionnaires were mailed in December 1991; 100 completed questionnaires have been received by SCPD and provided to us for use in the benefit analysis. (See Attachment 1 to this section.) These results helped the analysis identify the concerns of the boaters; in addition, tabulation of these results were used to quantify parameters used in the evaluation; specifically, increase in fish catch and recreation.

5.4.1 Increased Navigation Use

There are approximately 1100 vessels berthed at Santa Cruz Harbor year round of which 1,000 are berthed permanently and 100 are transient. Of the permanently berthed vessels, for which benefits are claimed, 20 percent are commercial fishing boats, and 80% recreational boats. For the benefits categories that have been identified, the assessed magnitude of the annual benefits are:

(a) Savings in delay time	$ 50,000
(b) Increase in fish catch	$ 96,000
(c) Charter boats	$ 5,000
(d) Recreation	$ 43,000
(e) Safety	N.A
Total	$194,000

Savings in Delay Time. The savings in delay time are limited to the 200 commercial boaters. Under existing conditions there are approximately 10 days per year that commercial fishermen encounter delays of approximately 20 minutes per trip. The operating costs of the commercial boats are estimated to be approximately $75 per hour. The annual benefit equals 200 (boats) x 10 (trips) x 1/3 (hours) x $75/hour = $50,000.

Increase in Fish Catch. The estimate for the increase in fish catch is based on Table 18 of the annual fish catch report prepared by the California Department of Fish and Game which specifies the species of fish caught commercially at Santa Cruz and their value. In 1990, considered to be a representative year, approximately 4.5 million pounds of fish were reported caught at Santa Cruz, valued at $2.3 million. The Santa Cruz boater survey indicated that the fishermen would actively fish approximately 10 more days per year under ideal entrance conditions which equates to a 10% increase in effort. Consultations were conducted with the regional representative of the California Department of Fish and Game. It was determined based on these discussions that a significant portion of the fish landed at Santa Cruz would not be affected by improved entrance conditions due to seasonality considerations and the quota restrictions on specific species of fish. Of the 4.5 million fish landed at Santa Cruz approximately 2 million of these, potentially, could increase with additional fishing effort. Based on these discussions it was determined that a 10% increase in fishing effort would result in an increase in fish catch of 207,000 pounds valued at $96,000.

Charter Boats. Of the several charter boat companies operating out of Santa Cruz Harbor, two continue to have operating problems and economic (NED) losses associated with the current shoaling problems.

These two charter companies have relatively deeper draft vessels which have been and will continue to be impacted at times by shoaling within Santa Cruz Harbor. Approximately 10 to 12 charters per year are cancelled due to the shoaling, for each company. Typically, two of these trips are permanently lost and not made up later. The average economic (NED) loss is $1,250 per trip. For each company the NED loss is $1,250 x 2 = $2,500, or $5,000 per year for the two companies.

Recreation. While there are approximately 800 recreational boaters, based on the survey many do not recreate during the winter months when shoaling occurs, nor do they intend to even under ideal entrance conditions. However, for those that do, there will be some additional opportunity to recreate during the winter months. We have determined that approximately 330 of the recreational boats will use the harbor 5 additional days. Also, the survey indicates that on average there are on average 2.7 people per boat. Based on the recreation evaluation guidance (Chapter 6: ER 1105-2-100), the unit day value of this specialized recreation is $9.60.

The total annual estimated recreation benefit for Santa Cruz Harbor associated with year-round improved maintenance is 330 (trips) x 2.7 (people) x 5 (days) x $9.60/day = $43,000.

Safety. A safety concern exists under current conditions at Santa Cruz Harbor which could be relieved by a project. The harbormaster has indicated that three lives have been lost due to boating accidents in the harbor entrance. The potential for

capsizing or running aground still exists. For the past several years, at least one month of each winter season has had dangerous conditions. Under such conditions, patrol boats must stop traffic and provide warnings, especially to those vessels from out of the area. Typically, since 1985, there have been 150 patrol boat response cases annually, 20 percent occurring within the harbor and harbor entrance. Waves breaking at the entrance also attract surfers; the commingling of boats and surfers in the entrance creates another dangerous situation.

A calmer entrance would provide for safer boating conditions as well as discourage surfers from using the harbor area. While this may result in some minor reductions in patrol time, under current Corps practices no monetary benefit can be claimed for a general increase in safety.

5.4.2 Savings in Dredge Costs

The other aspect of the quantification of the economic benefits is the value of substituting an alternative dredging system (at a lower cost) for some of the current dredging. For purposes of the economic evaluation, the benefit would be the net savings in variable costs by a partial substitution/elimination of the existing dredging.

A benefit is claimed for savings in operation of the dredge _Seabright_. It is anticipated that an alternative system would not replace the _Seabright_ but would make it possible for the _Seabright_ to operate less often and save costly operating hours. For practical purposes it is necessary to develop this estimate on a unit basis (cost or savings per cubic yard of dredging) and there are several estimates of the cost per cubic yard of dredging the entrance at the Santa Cruz Harbor. Actually, we should use the _change_ in variable cost with respect to the change in yards dredged. Without a very sophisticated economic model to isolate, in controlled situations, the operating cost for the _Seabright_ with different quantity requirements we must rely on annual estimates of variable cost (per cubic yard) for dredging of the entrance channel. It should be recognized that this unit variable cost is not a true constant: initially, unit costs will be high due to start-up costs; then, the first material to be dredged is in shallow waters and most accessible, which causes average unit costs to decrease. Finally, as the dredging operation extends deeper in the entrance and to the edges of the dredged area, the unit costs will again increase. Typically, companies attempt to structure their operations so that they are beyond the point where unit costs are decreasing, but where they are still "low". Also, some costs, while variable, do not necessarily change smoothly and uniformly with the size of the operation. For example, some maintenance of equipment is performed irrespective of use, and labor is hired and fired not per cubic yard, but basically on a fixed-time contract

covering an extended period. Nonetheless, for the purposes of this evaluation, we have developed a single unit variable cost of the current dredging program in order to evaluate the "substitution" benefit.

Since the acquisition of the Santa Cruz Harbor dredge, Seabright, there have been five dredging years, 1986-87, through 1990-91. (See Annual Dredge Reports, Santa Cruz Port District.) Simply comparing the Santa Cruz Port District's variable costs and cubic yards, the annual average variable cost is between $1.09 and $1.58; adjusting for inflation, the range is between $1.25 and $1.65. It should also be noted that it is not the intention of any alternative to replace the Seabright, and the most any alternative is projected to reduce the dredge operations is one month per year. With a with-project condition utilizing one of the alternatives developed during this study, the Seabright might start operating, for example, two weeks later and end two weeks earlier. The variable cost of one month's operation of the dredge has been determined by the Port District to be $75,000. This value is considered a "cap" or upper limit on the annual replacement benefit.

Unit Cost. Using the Santa Cruz Harbor District's calculations of variable cost for FY 87 through FY 91 from their annual reports, the average variable cost is $1.40. This is used as a variable saving up to the "cap" of $75,000.

5.4.3 Benefits by Alternative

Six possible action alternatives have been identified as part of this study. Each potentially contributes to the two benefit categories, Navigation and Savings in Dredging. These alternatives and their impacts are described more fully elsewhere in the report. The tabulation below provides a summary of the benefits gained per alternative in the two benefit categories.

TABLE 5.8
ANNUAL BENEFITS BY ALTERNATIVE

Alternative	Navigation Total = $194,000 (%)	Sav'gs in Dredging basis $1.40/yd Max. $75,000	Total
1 - No Action	NA	NA	0
2 - Seal E. Jetty	0	$7,000	$7,000
3 - Pipeline	0	$14,000	$14,000
4 - Channel Sand Trap	$194,000 (100)	0	$194,000
5 - Offshore Sand Trap	$194,000 (100)	$75,000 (Max.)	$269,000
6 - Fixed Jet-Pumps	$194,000 (100)	$75,000 (Max.)	$269,000
7 - Mobile Jet-Pump	$97,000 (50)	$70,000	$167,000

ATTACHMENT 1

SCSURVEY

Santa Cruz Harbor Survey

1) Type of Boat?
[] Motor
[] Sail
[X] Sail w/ auxilliary
[] Self Propelled

Length: 22

Draft:

(Optional)
Name:
Address:

Phone No:

2) Primary Use: [] Commercial [] Recreational

3) What is your primary boating activity when leaving the harbor?
[] Fishing [] Diving [X] Cruising/Sailing [] Other______________

4) If you fish, what species of fish do you catch?(total lbs/yr?)

SPECIES	LBS/YR	SPECIES	LBS/YR

5) On average, how many people are on board (including self)? 4

6) How many times per year do you use your boat on open water? 40

7) How many days each month do you take your boat out of the Santa Cruz harbor entrance?

Months:	J	F	M	A	M	J	J	A	S	O	N	D
No of Days:	4			→	6	6	6	6	6			

8) Does harbor shoaling or wave-breaking in the channel affect your activities? Yes [] No [X] Please describe any incidents after 11/86, giving dates, wave heights and portion of entrance affected by breaking, plus dollar damage, if any.

9) Does the current dredging practice (5mo/yr during winter since 11/86) affect your activities moving in/out or around the harbor?
[] Yes [X] No Please explain.

10) How many more days per year would you use Santa Cruz harbor if a fully maintained, year-round solution to the shoaling problem were found? [X] 0 [] 1-5 [] 6-10 [] 11-20 [] more than 20

also see back page...

Please use extra sheets of paper for additional comments to any questions

11) Please comment on some of the alternatives that are being considered individually and in combination.

a. Continuing the present dredging program

b. Jet pumps - an all-weather supplement which dredges harbor sands. This system would also reduce wave breaking at the harbor entrance

c. Sealing west and/or east jetty to halt sand movement through them.

d. Extending the present dredge discharge pipeline toward Black's Point to reduce westerly moving sand from re-entering the harbor.

e. A sand trap (pit) preferably located in the harbor entrance, ie. overdredging entrance, to provide additional sand storage and reduce entrance wave breaking.

f. Other Solutions????

12) We are working with the Corps of Engineers on the shoaling and surge problems at Santa Cruz harbor. Are there any other problems that we might address concerning Santa Cruz harbor?

Please return completed survey to Santa Cruz Port District, 135 5th Avenue, Santa Cruz, CA, 95062 (a self-addressed, stamped envelope is provided).

5.5 Environmental Considerations

5.5.1 General

For all of the alternatives except the Offshore Sand Trap, adverse environmental impacts are expected to be of small consequence and temporary. If the Offshore Sand Trap is selected for further study, the environmental impact to the submarine habitat will have to be addressed and the appropriate mitigation measures developed.

5.5.2 Endangered Species

None of the project alternatives will have any direct impact on individuals or critical habitat of any species protected by state or federal law, or of any species of special concern. There is the possibility that the Offshore Sand Trap alternative may have some adverse impact on marine mammals foraging in the trap or disposal areas.

5.5.3 Cultural Resources

The only possible cultural resources in the project area are shipwrecks. All of the alternatives except the Offshore Sand Trap are sited in places which have been previously disturbed or filled. Appropriate survey work to verify the presence or absence of shipwrecks or artifacts will have to be undertaken prior to excavation of the Offshore Sand Trap.

5.5.4 Conclusions

The Offshore Sand Trap will require an environmental impact statement and the development of mitigation to compensate for the loss of benthic habitat. The other alternatives, either singly or in combination, are not expected to have any significant adverse impacts. For additional information, a Preliminary Environmental Assessment is attached as Appendix C.

6.0 COORDINATION, PUBLIC VIEWS AND COMMENTS

At the initiation of the study, a public workshop was held at the harbor on 16 July 1991. Over 2,000 public notices were distributed in advance of the workshop, including to all harbor tenants, and to governmental agencies and other organizations known to be concerned with the area. The meeting itself was attended by about 30 non-Corps individuals, a number of whom were representing local groups or agencies.

After preliminary information was in hand concerning several alternatives under study, an all-day working meeting was held on 31 October 1991 with the local sponsor's Dredging Committee, at their offices in Santa Cruz.

During the fall of 1991, the Port District distributed a survey form, soliciting information that would be relevant to the study. Approximately 200 copies were distributed, representing a sample of about 20% of the permanent berth holders in the harbor. About one-half of the forms were returned and provided to the Corps for analysis. Responses provided information about individual's current use of the harbor, how they were affected by current dredging practices, and their opinion about the various improvements under consideration.

To further assess local concerns with the shoaling problem and with potential solutions to the problem, a professional social scientist was hired to conduct in-depth interviews with all major groups and classes of users of the harbor. Approximately 25 such interviews were held with a representative sample of harbor users and adjacent property owners. Most of those interviewed had been active in the harbor for more than 10 years. A report summarizing the findings of these interviews (Joseph, 1992) is attached as Appendix D.

The input received from the public workshop, working meeting, Port District survey, and social scientist interviews has been summarized in Section 3.2 (Local Needs and Desires) and Section 4.2 (Local Views and Preferences of Study Alternatives).

7.0 CONCLUSIONS

The results of this reconnaissance study indicate that shoaling at the jettied entrance to Santa Cruz Harbor is detrimental to safe navigation. The benefits associated with improving this navigation problem, however, are relatively low. Evaluations have been made of alternatives aimed at improving entrance conditions. The focus of this effort has been on those potential solutions judged to be beyond the purview of the Port District's legal responsibility to maintain the channel under the 1986 Cooperative Agreement with the Department of the Army. Of the alternatives evaluated, installation of a fixed jet-pump system has been credited with the highest benefit-to-cost (b/c) ratio. The b/c ratio for this alternative, however, is only 0.65 to 1.0, suggesting no Federal interest.

On the other hand, some small-scale solutions which are judged to be within the Port District's purview may merit further consideration. These solutions include the following: (1) constructing dune fencing along the west jetty and establishing additional windward dune plantings; (2) creating channel sand traps when their creation can be accommodated within the existing priorities and budget for the dredge; and (3) extending the discharge pipeline to the east provided that the lands required for offseason storage of the additional pipe are "dedicated," i.e., the Port District does not have some other high-value, revenue-generating use for these lands.

8.0 RECOMMENDATIONS

Based on the results of the reconnaissance study, Federal participation in further study under the operant authority is not recommended. This document fully responds to the study authority.

26 May 92
Date

Stanley G. Phernambucq
Colonel, Corps of Engineers
District Engineer

9.0 REFERENCES

California Department of Fish and Game, 1991, Annual Report Fish Catch by Species for Santa Cruz Harbor (Table 18), Marine Resources Division, Long Beach, CA.

Castel,D., J.O. Thomas, and R.J. Seymour, 1991, Coastal Data Information Program, Santa Cruz Harbor Array, Oct 1977-Oct 1991, Prepared for the U.S. Army Corps of Engineers and the State of California Department of Boating and Waterways by Ocean Engineering Research Group, Institute of Marine Resources at Scripps Institution of Oceanography, La Jolla, CA, November 1991.

Clausner, J.E., J.A. Gebert, A.T. Rambo, and K.D. Watson, 1991, "Sand Bypassing at Indian River Inlet, Deleware," Coastal Sediments '91, Proceedings of a Specialty Conference on Quantitative Approaches to Coastal Sediment Processes, Seattle, Washington, June 25-27, 1991 American Society of Civil Engineers, New York, NY, pp 1177-1191.

Davis, J., 1992, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, personal communication with T. Kendall, January 7, 1992.

Ebersole, B. A., M.A. Cialone, and M.O. Prater, 1986, RCPWAVE - A Linear Wave Propagation Model for Engineering Use, Technical Report CERC-86-4, Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS

Garcia, A.W., and J.R. Houston, 1975, Type 16 Flood Insurance Study: Tsunami Predictions for Monterey and San Francisco Bays and Puget Sound, Technical Report H-75-17, Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, November 1975.

Griggs, Gary B., 1987, "Littoral Cells and Harbor Dredging Along the California Coast," Environ Geol Water Sci, Volume 10, Number 1, Springer-Verlag, New York, NY, pp 7-20.

Griggs, G.B. and T.C. Best, "A Sediment Budget for the Santa Cruz Littoral Cell, Special Volume in Memory of F.D. Shepard (In Press), 1990.

Inman, D.L., 1976, Summary Report of Man's Impact on the California Coastal Zone, prepared for the California Department of Navigation and Ocean Development [CA Boating], Sacramento, CA, November 1976.

Joseph, G, 1992, Draft Final Report Social Environment Study, Santa Cruz Harbor Shoaling Reconnaissance Study, prepared for U.S. Army Corps of Engineers, San Francisco District, San Francisco, CA, March 1992.

Kendall, T., and J. Cole, 1990, "Synopsis of Central and Northern California Coastal Storms: January 21 - February 7, 1990," Newsletter of the California Shore and Beach Preservation Association, Santa Cruz, CA, June 1990.

Mariano, J., 1988, Sphere of Influence Study for the Santa Cruz Port District, prepared for the Santa Cruz Port District Commission, Santa Cruz, CA, December 1988.

Melo, E and R.T. Guza, 1991, "Wave Propagation in Jettied Entrance Channels II: Observations," Journal of Waterway, Port, Coastal, and Ocean Engineering, American Society of Civil Engineers, New York, NY, Sept./Oct. 1991, pp 493-510.

Moffatt & Nichol, Engineers, 1978, Santa Cruz Harbor Shoaling Study, prepared for U.S. Army Corps of Engineers, San Francisco District, San Francisco, CA, June 1978.

Moffatt & Nichol, Engineers, 1992, Santa Cruz Harbor Shoaling Study, Harbor Entrance Sediment Budget, prepared for Aqua Resources, Inc., Berkeley, CA, under contract with U.S. Army Corps of Engineers, San Francisco District, San Francisco, CA., March 1992.

Patterson, D.R., D.R. Bisher, and M.R. Brodeen, 1991, "The Oceanside Experimental Sand Bypass System, The Next Step," Coastal Sediments '91, Proceedings of a Specialty Conference on Quantitative Approaches to Coastal Sediment Processes, Seattle, Washington, June 25-27, 1991, American Society of Civil Engineers, New York, NY, pp 1165-1176.

Santa Cruz Planning Commission, Santa Cruz 2005 General Plan, Draft General Plan prepared for the City of Santa Cruz, Santa Cruz, CA, October 1991.

Santa Cruz Port District, Annual Dredging Reports, prepared by the Santa Cruz Port District, Santa Cruz, CA, 1987, 1988, 1989, 1990, 1991.

Santa Cruz Port District, 1992, Santa Cruz Harbor Survey, A survey of Boater Opinions 1991-92, conducted by the Santa Cruz Port District, Santa Cruz, CA

U.S. Army Corps of Engineers, 1960, "Geology, Soils, and Construction Materials: Appendix 1": in Santa Cruz Harbor, California: Design Memorandum No. 1, U.S. Army Corps of Engineers, San Francisco District, San Francisco, CA, December 1960, pp 1-27.

U.S. Geological Survey, 1985, Geomorphology Framework Report, Monterey Bay, Ref No. CCSTWS 85-2, prepared for U.S. Army Corps of Engineers, Los Angeles District, Los Angeles, CA, December 1985.

PHOTOGRAPHS

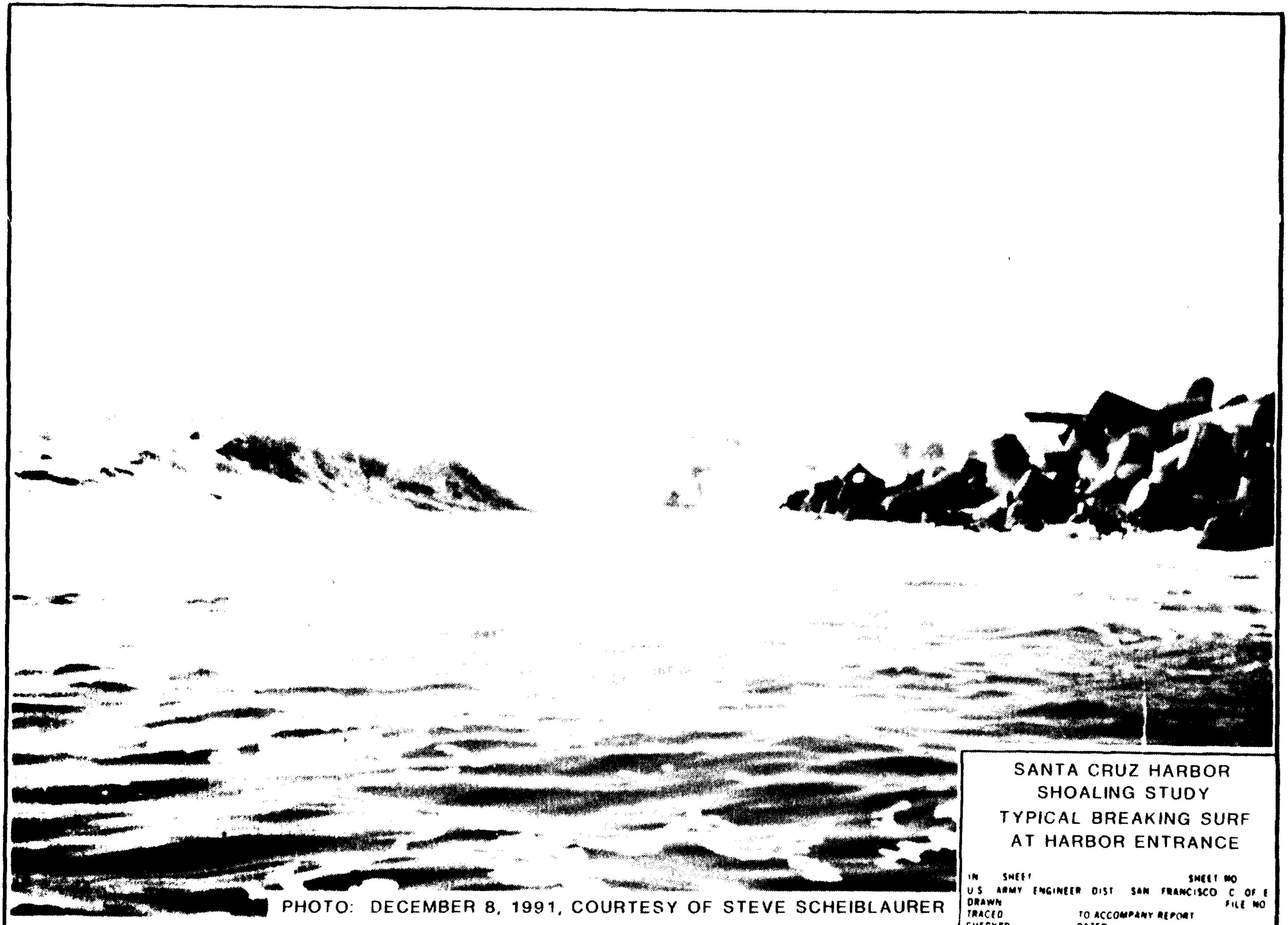


PHOTO: DECEMBER 8, 1991, COURTESY OF STEVE SCHEIBLAURER

SANTA CRUZ HARBOR
SHOALING STUDY
TYPICAL BREAKING SURF
AT HARBOR ENTRANCE

IN SHEET SHEET NO
U.S. ARMY ENGINEER DIST SAN FRANCISCO C. OF E
DRAWN FILE NO
TRACED TO ACCOMPANY REPORT
CHECKED DATED

PHOTO NO. 1

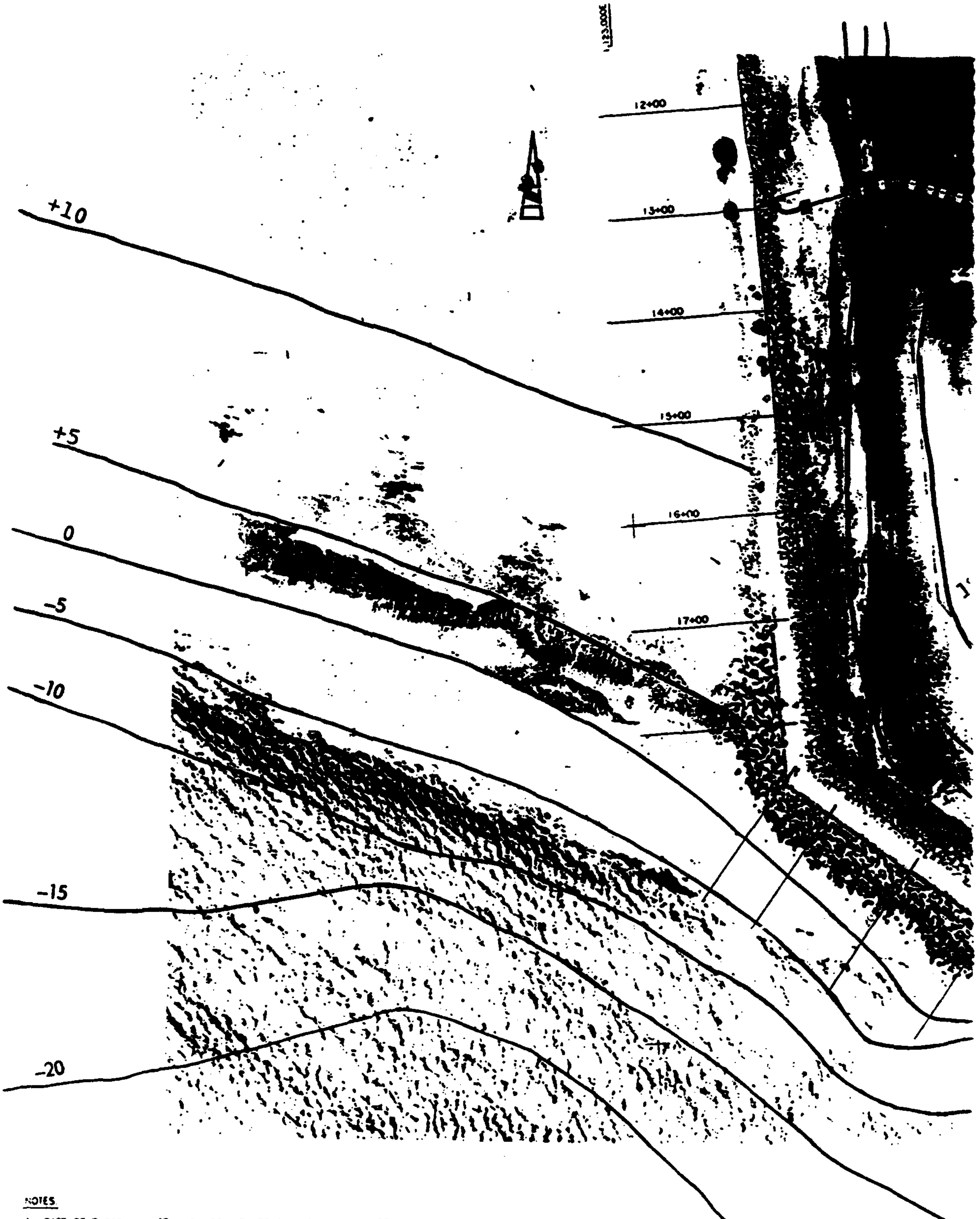
PHOTO: OCTOBOR 1983, COURTESY OF BILL LEE

SANTA CRUZ HARBOR
SHOALING STUDY
EXTREME BREAKING SURF
AT HARBOR ENTRANCE

U.S. ARMY ENGINEER DIST SAN FRANCISCO C OF E
DRAWN FILE NO
TRACED TO ACCOMPANY REPORT
CHECKED DATED

PHOTO NO. 2

PLATES



NOTES

1 DATE OF PHOTO - MARCH 13, 1991. PHOTO BY AERIAL PHOTOMAPPING SERVICES, CLOVIS, CALIFORNIA

2 CHANNEL DEPTH CONTOURS REPRESENT TYPICAL POST DREDGE CONDITION AND APPROXIMATE NAVIGATION CHANNEL LIMITS BASED ON A REVIEW OF SURVEY DATA PROVIDED BY THE CORPS OF ENGINEERS AND SANTA CRUZ HARBOR DISTRICT

3. NEARSHORE CONTOURS DEVELOPED FROM BEACH PROFILE SURVEYS BY GARY GRIGGS, ET AL. NOVEMBER, 1991.

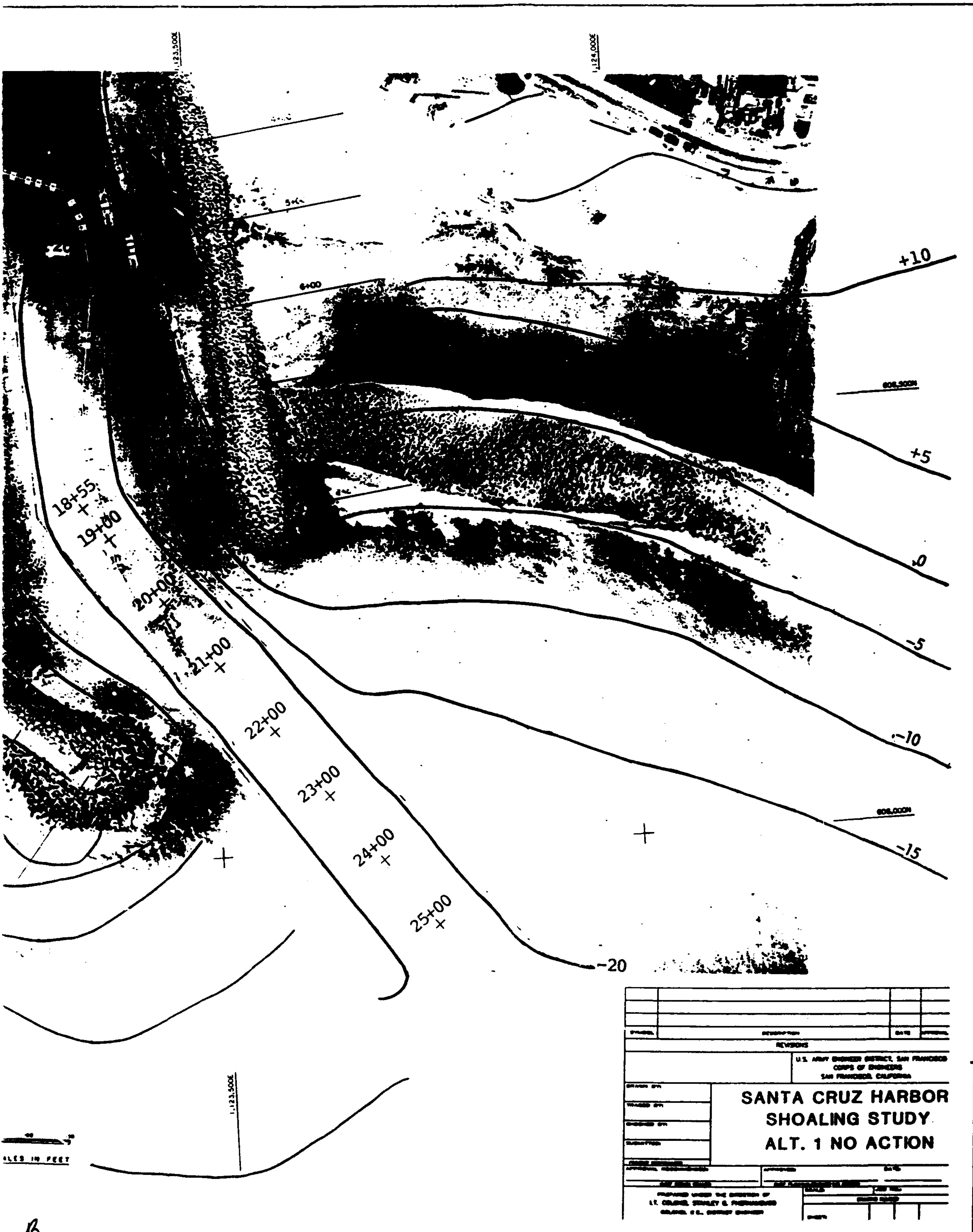
4. COORDINATES ARE REFERENCED TO CALIFORNIA COORDINATE SYSTEM AND WERE TAKEN FROM COE SURVEY DATED MAY 18-18, 1978.

5. ELEVATION REFERENCED TO MEAN LOWER LOW WATER DATUM

1,123,000E

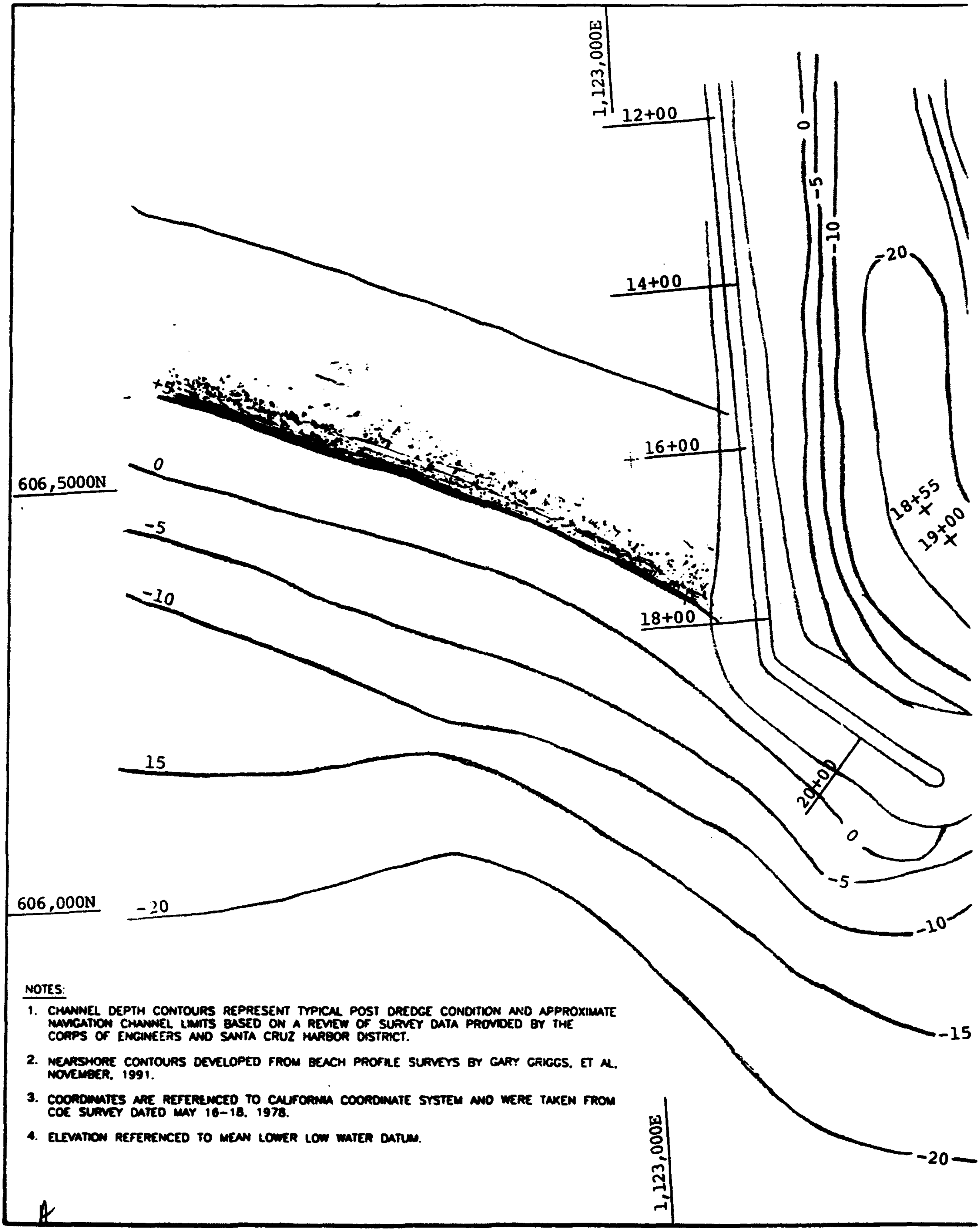
GRAPHIC SCALES IN FEET

A



+10
+5
0
-5
-10
-15
-20
18+55
19+00
20+00
21+00
22+00
23+00
24+00
25+00
SANTA CRUZ HARBOR
SHOALING STUDY
ALT. 1 NO ACTION

PLATE 1



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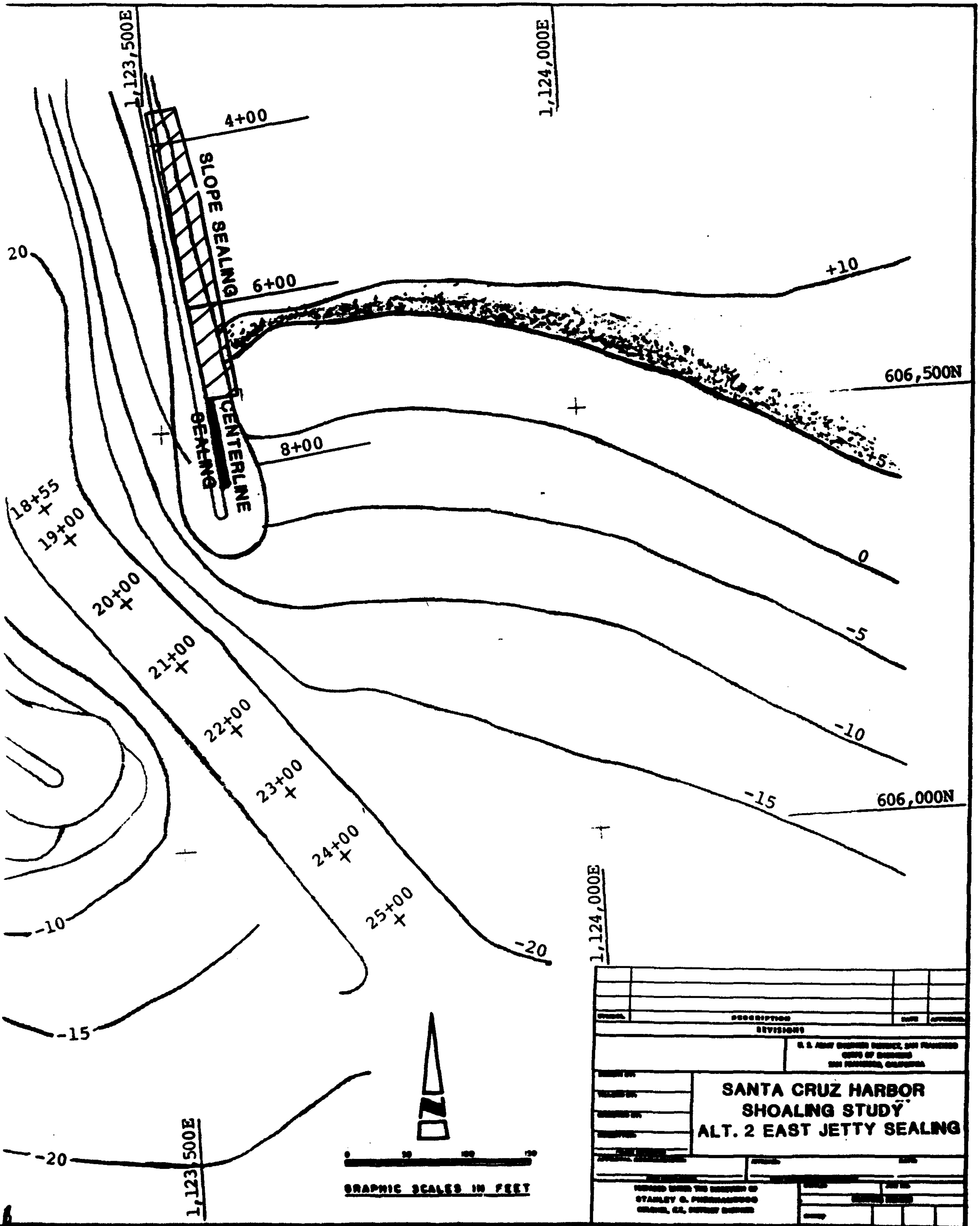
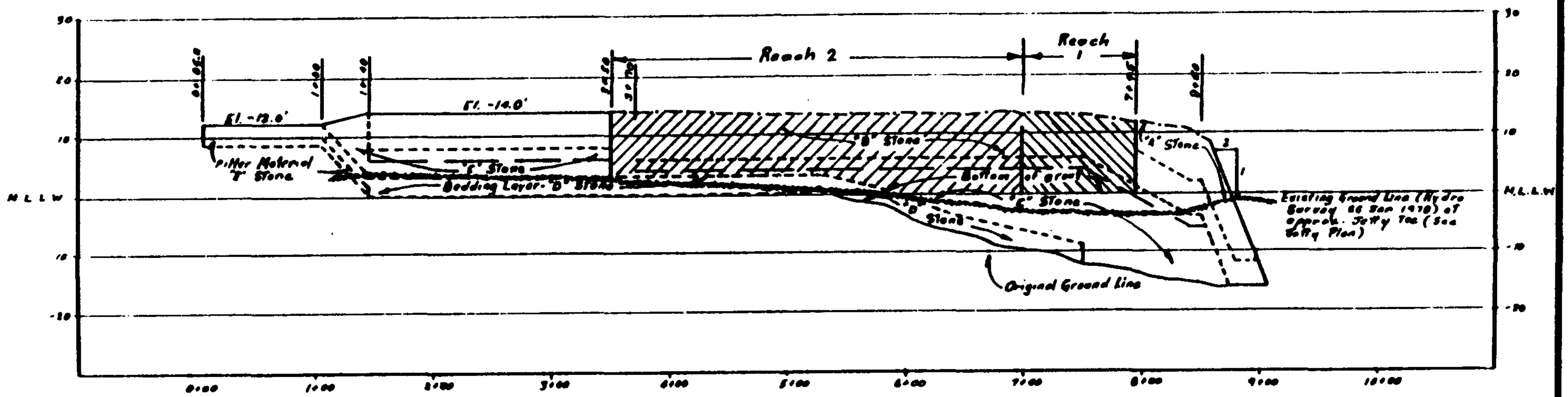


1,123,500E
1,124,000E
4+00
SLOPE SEALING
6+00
+10
606,500N
+5
CENTERLINE
SEALING
8+00
0
-5
-10
-15
606,000N
-20
20
18+55
19+00
20+00
21+00
22+00
23+00
24+00
25+00
-10
-15
-20
1,123,500E
1,124,000E
N
GRAPHIC SCALES IN FEET
SANTA CRUZ HARBOR
SHOALING STUDY
ALT. 2 EAST JETTY SEALING

PLATE 2a



℄ PROFILE

SANTA CRUZ HARBOR

SHOALING STUDY

EAST JETTY SEALING

U.S. ARMY ENGINEER DIST. SAN FRANCISCO C. OF E.
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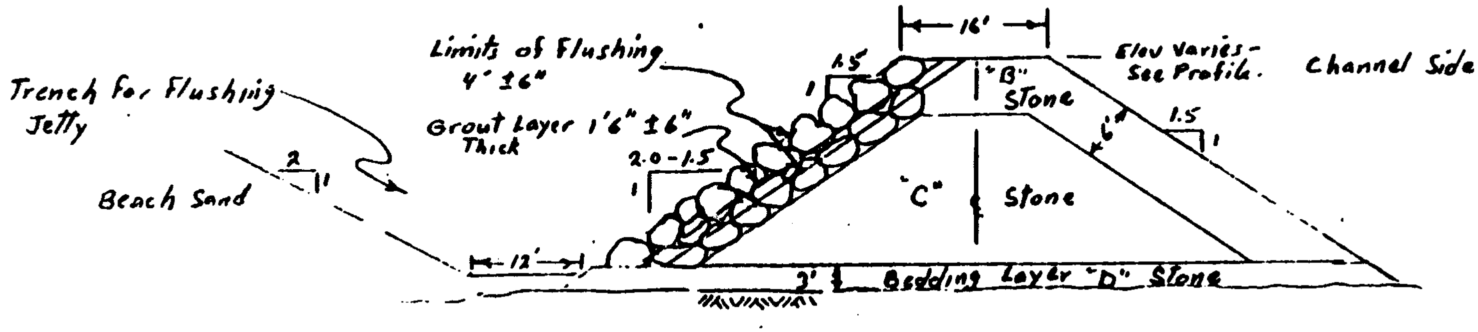
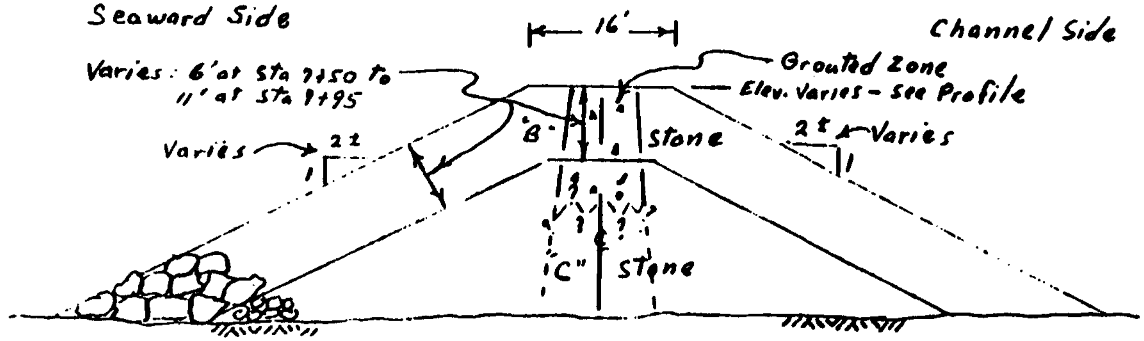
TRACED
CHECKED
TO ACCOMPANY REPORT
DATED
FILE NO.
ALT. 2

PLATE 2b



TYPICAL SECTION REACH 2

Sta 3+50 to Sta 7+00
Grout is Class II Concrete



TYPICAL SECTION REACH 1

Sta 7+00 to 9+95
Grout is Class I Concrete

Note: "B" Stone Avg 3 Tons, Min 2 Tons
"C" Stone Quarry Run to 2 Tons
"D" Stone Fines To 500 Pounds

SANTA CRUZ HARBOR
SHOALING STUDY
EAST JETTY SEALING

U.S. ARMY ENGINEER DIST. SAN FRANCISCO C OF E
DRAWN
TRACED
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TO ACCOMPANY REPORT
DATED
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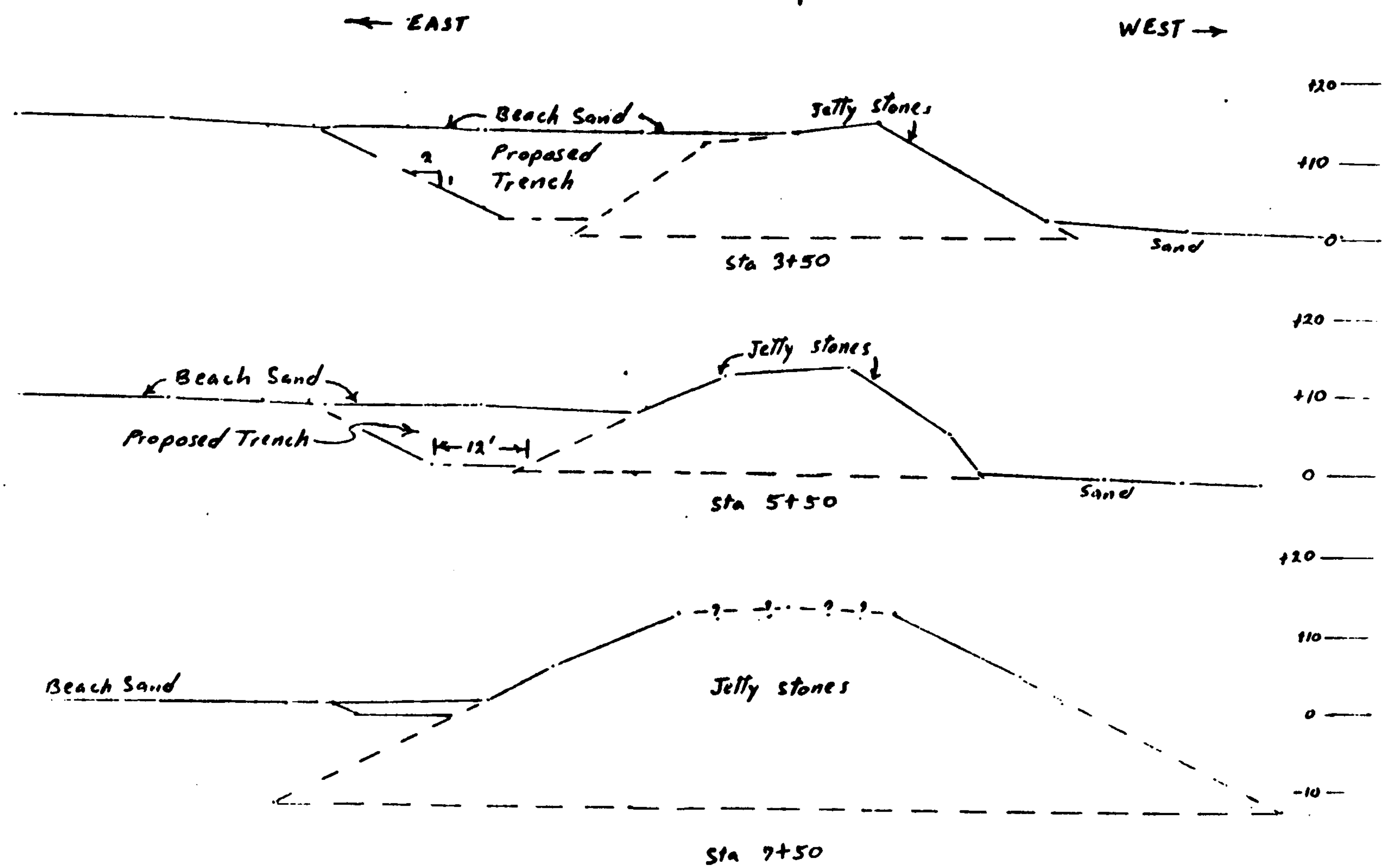
ALT. 2

PLATE 2c



Cross Sections Surveyed by Tronoff Assoc. on 30 March 1988; Elevations Based On MLLW Datum.

SANTA CRUZ HARBOR
SHOALING STUDY
EAST JETTY SEALING

U.S. ARMY ENGINEER DIST. SAN FRANCISCO C OF E
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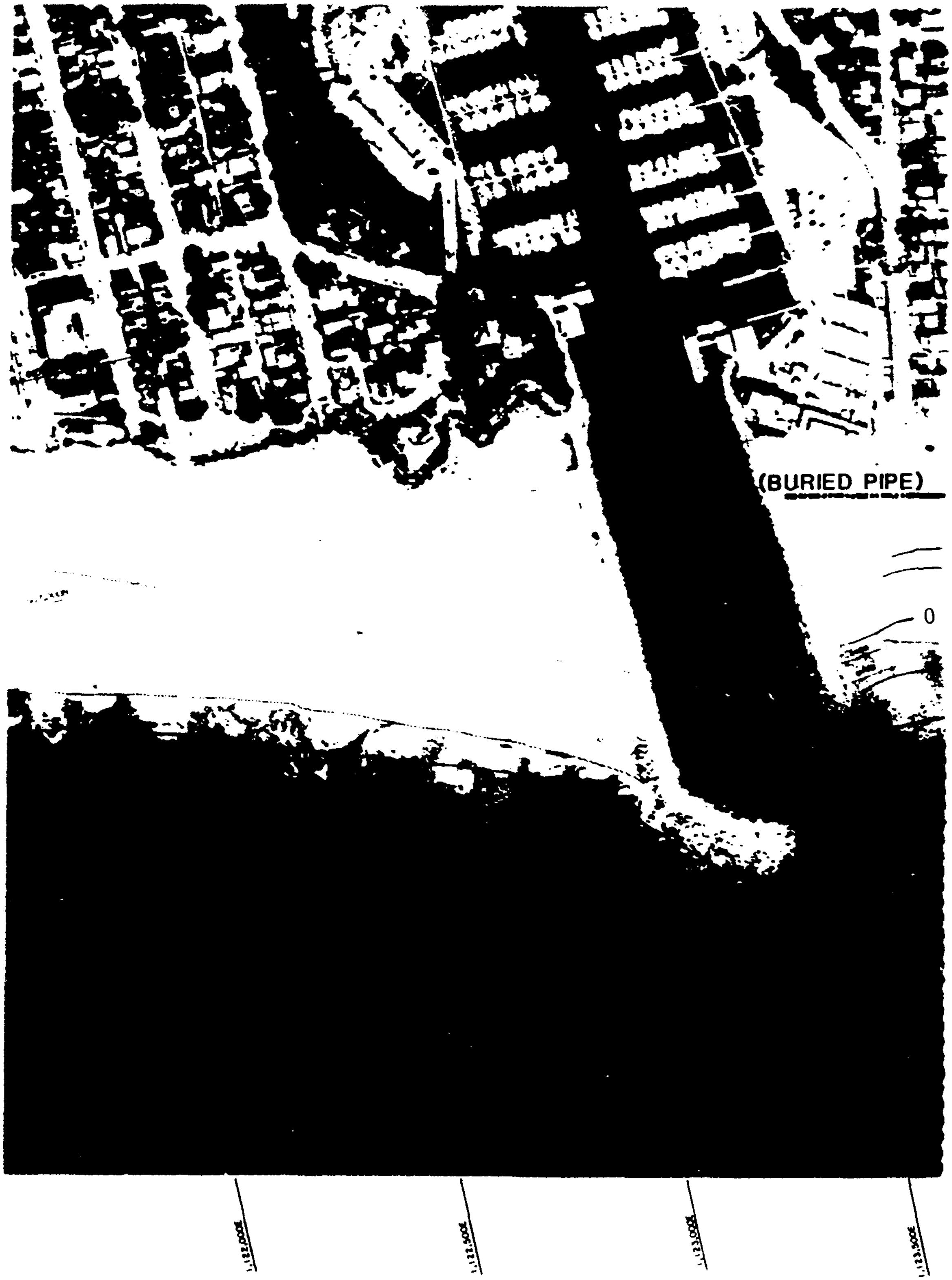
CHECKED DATED

PLATE 2d



NOTES:

1. DATE OF PHOTO – NOVEMBER 1, 1989. PHOTO BY AERIAL PHOTOMAPPING SERVICES, CLOVIS, CALIFORNIA.
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5. ELEVATION REFERENCED TO MEAN LOWER LOW WATER DATUM

A

GRAPHIC SCALES IN FEET

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DRAWN BY:
TRACED BY:
CHECKED BY:
SUBMITTED:

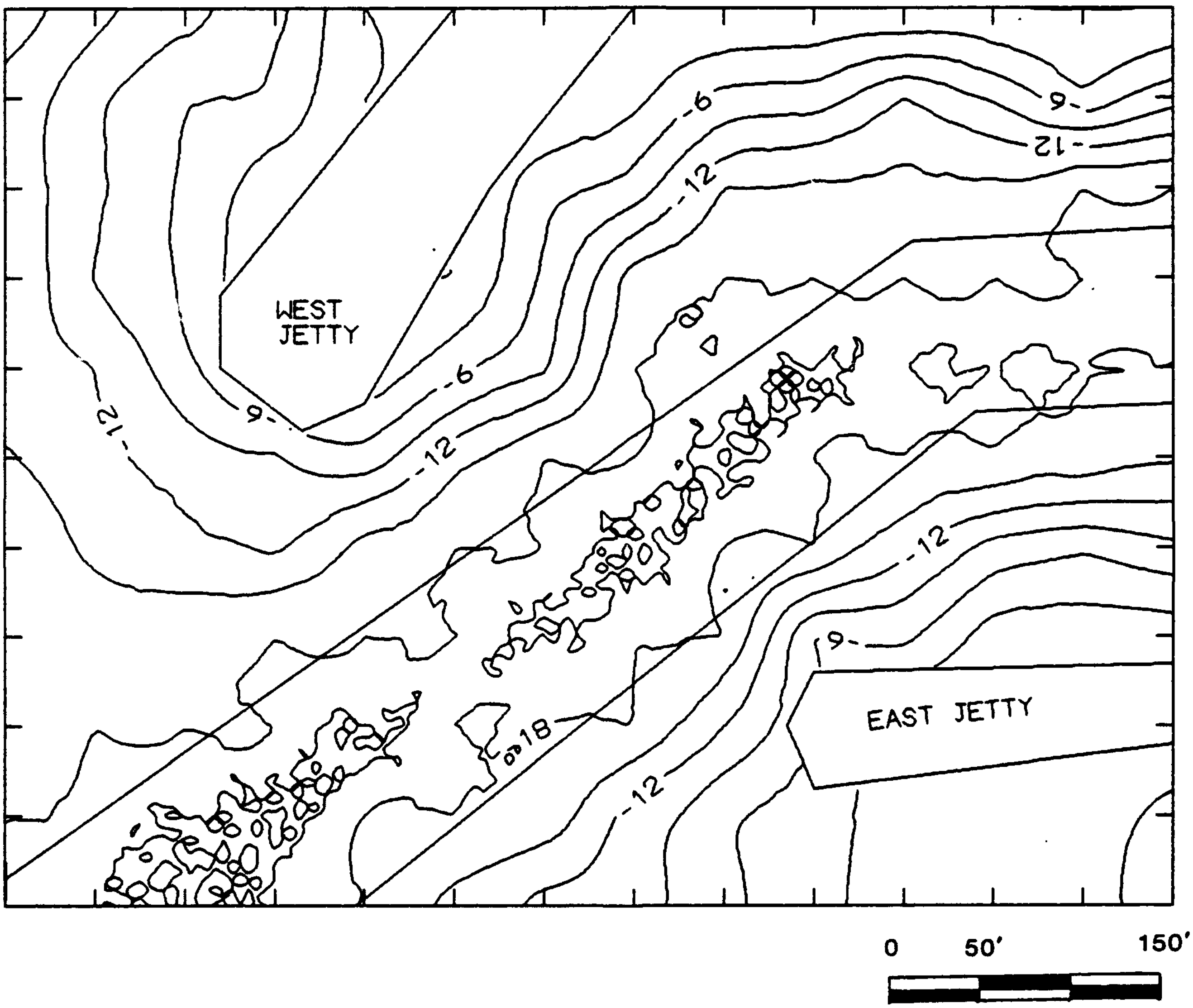
SANTA CRUZ HARBOR
SHOALING STUDY
ALT. 3 EXTENSION OF DREDGE DISCHARGE PIPELINE

APPROVAL RECOMMENDED:
APPROVED:
DATE:

PREPARED UNDER THE DIRECTION OF
STANLEY G. PHERNAMBUCQ
COLONEL, C.E., DISTRICT ENGINEER

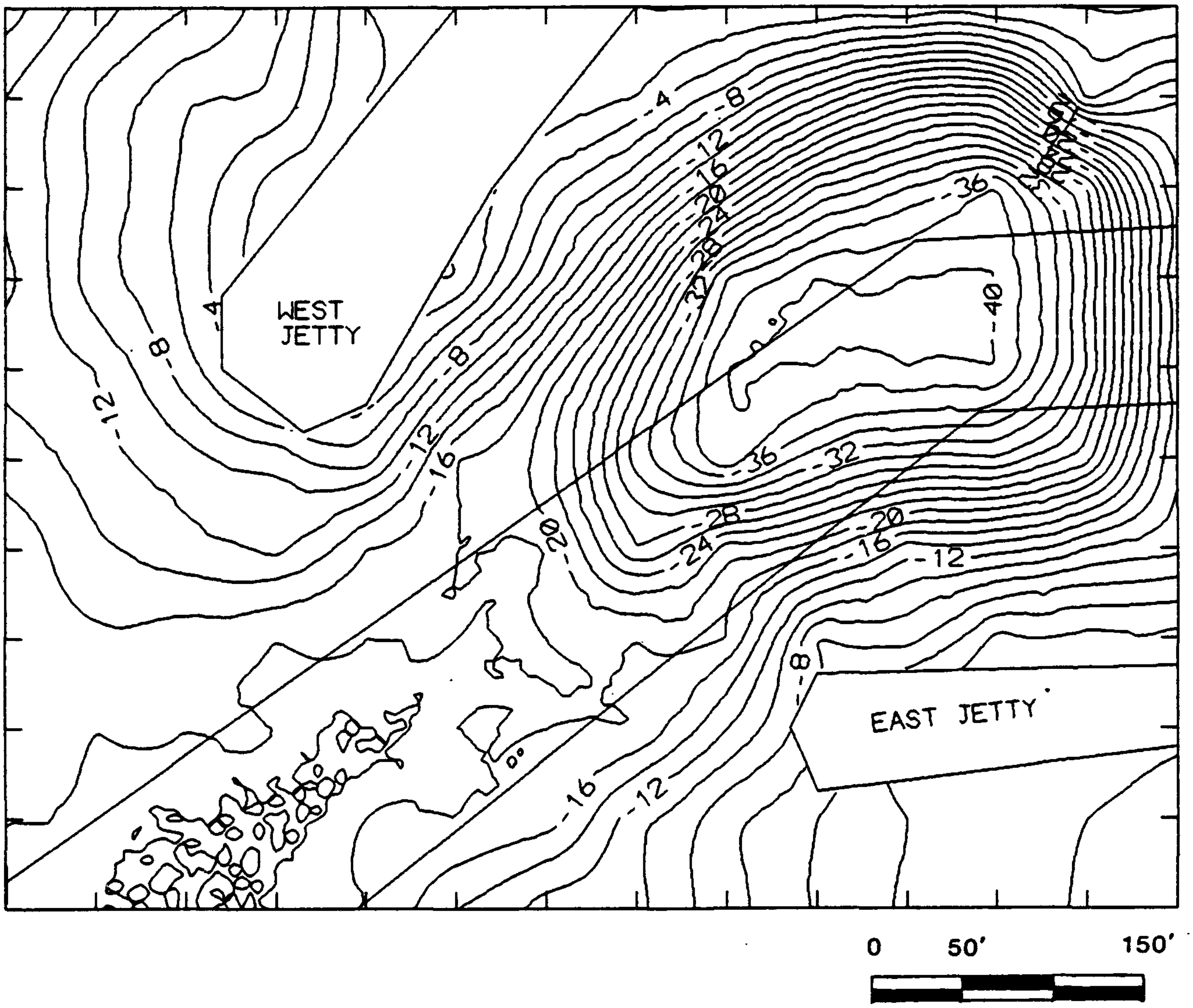
SCALE:
JOB NO.
DRAWING NUMBER
SHEET

PLATE 3



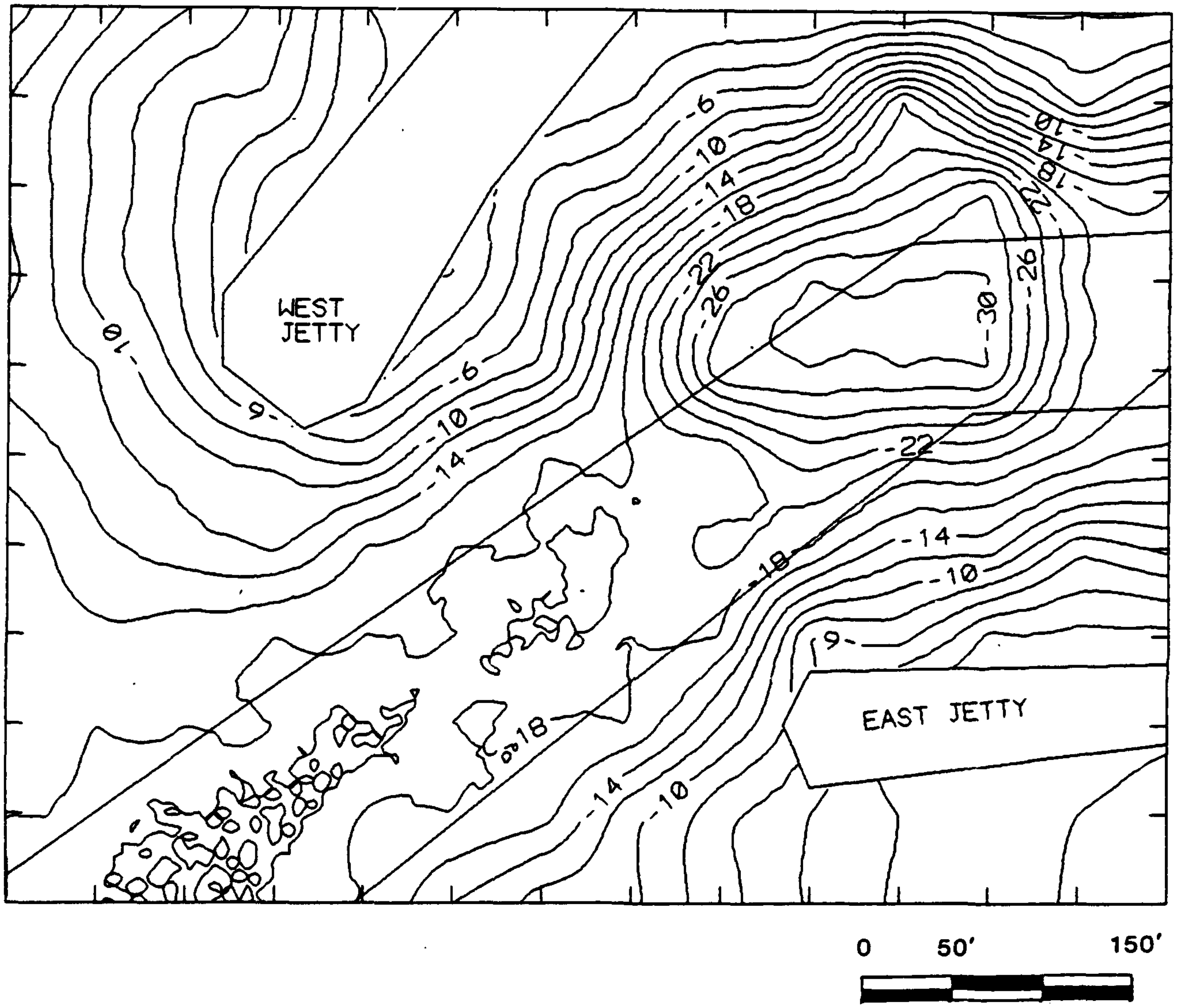
TYPICAL CHANNEL CONDITION (-18' MLLW)

PLATE 4a



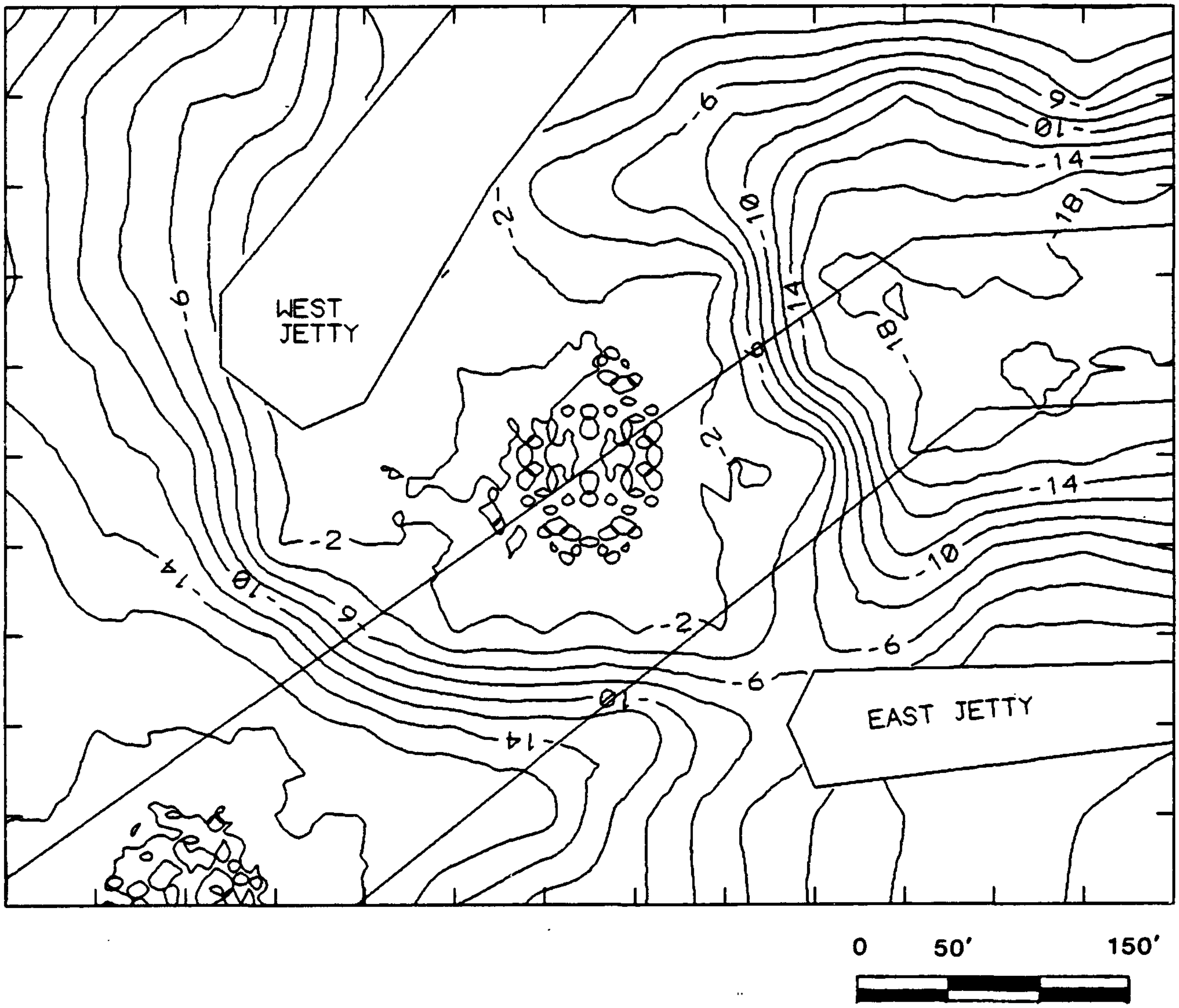
PROPOSED CHANNEL (w/ALT 4 SAND TRAP, -40' MLLW)

PLATE 4b



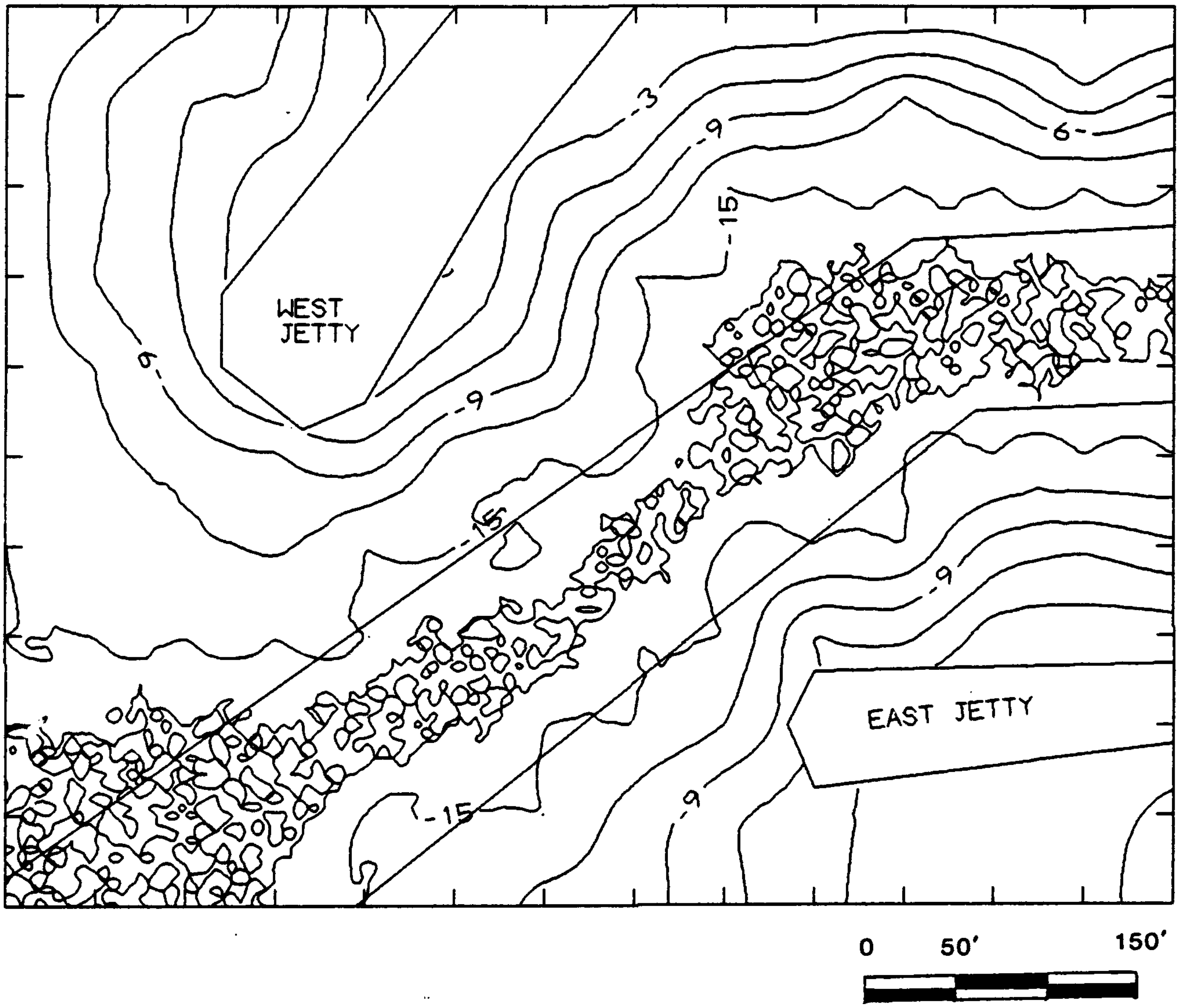
ANTICIPATED DEPTHS FROM PROPOSED CHANNEL SAND TRAP (ALT 4)

PLATE 4c



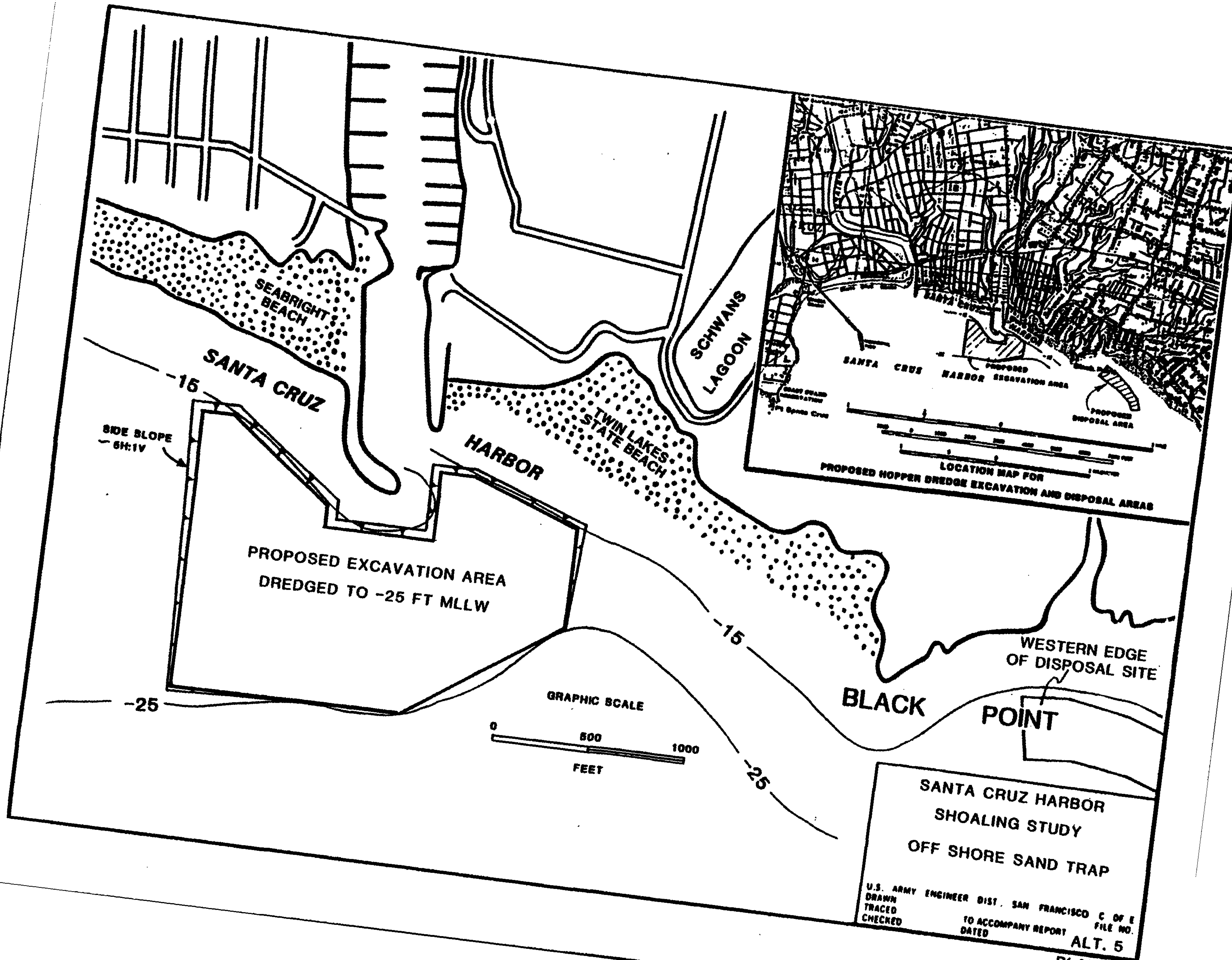
CLOSED CHANNEL CONDITION (-2' MLLW SHOAL)

PLATE 4d



HAZARDOUS CONDITIONS THRESHOLD (−15′ MLLW SHOAL)

PLATE 4e



SANTA CRUZ HARBOR
SHOALING STUDY
OFF SHORE SAND TRAP

U.S. ARMY ENGINEER DIST. SAN FRANCISCO C. OF E
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CHECKED
TO ACCOMPANY REPORT
DATED
FILE NO.
ALT. 5

PLATE 5a

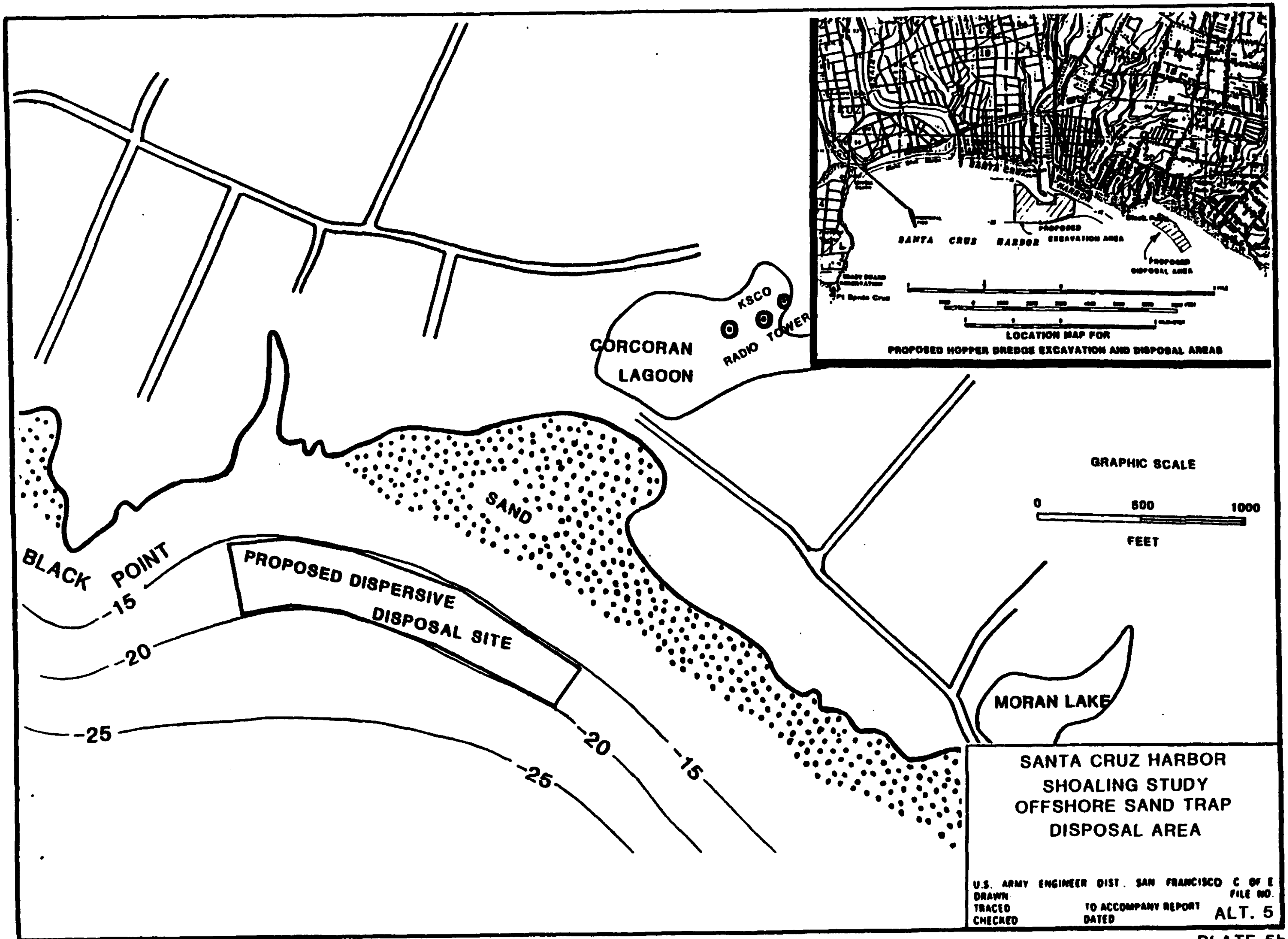
SANTA CRUZ HARBOR
PROPOSED EXCAVATION AREA
PROPOSED DISPOSAL AREA
LOCATION MAP FOR
PROPOSED HOPPER DREDGE EXCAVATION AND DISPOSAL AREAS
CORCORAN LAGOON
KSCO RADIO TOWER
GRAPHIC SCALE
0
500
1000
FEET
SAND
BLACK POINT
PROPOSED DISPERSIVE DISPOSAL SITE
-15
-20
-25
-20
-15
-25
MORAN LAKE
SANTA CRUZ HARBOR
SHOALING STUDY
OFFSHORE SAND TRAP
DISPOSAL AREA
U.S. ARMY ENGINEER DIST. SAN FRANCISCO C OF E
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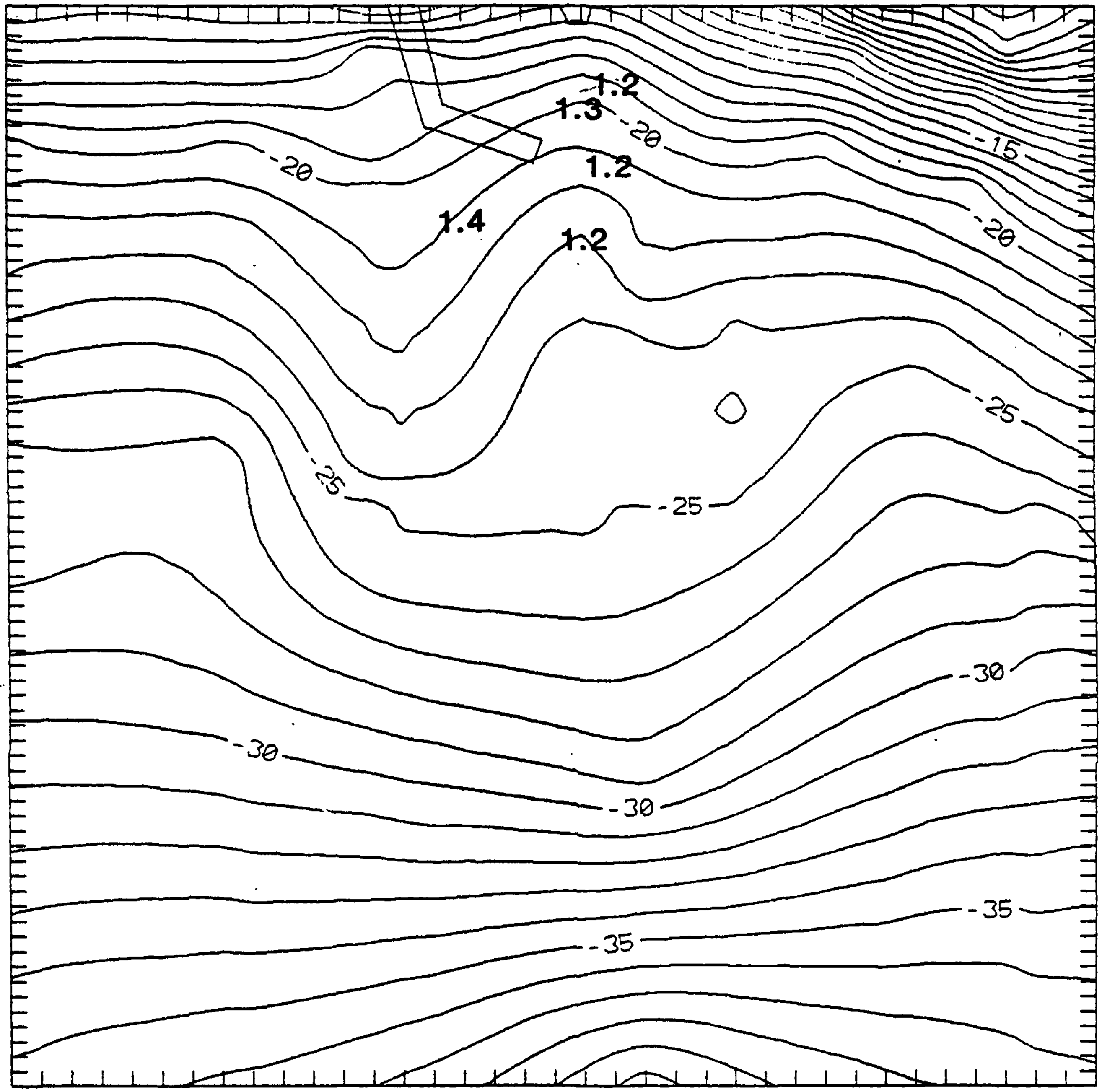
PLATE 5b



Wave Transformation Coefficients*
Pre-Harbor Bathymetry, 17 sec Waves From 215°

*Includes Refraction, Diffraction & Shoaling from RCPWAVE.

SANTA CRUZ HARBOR
SHOALING STUDY

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
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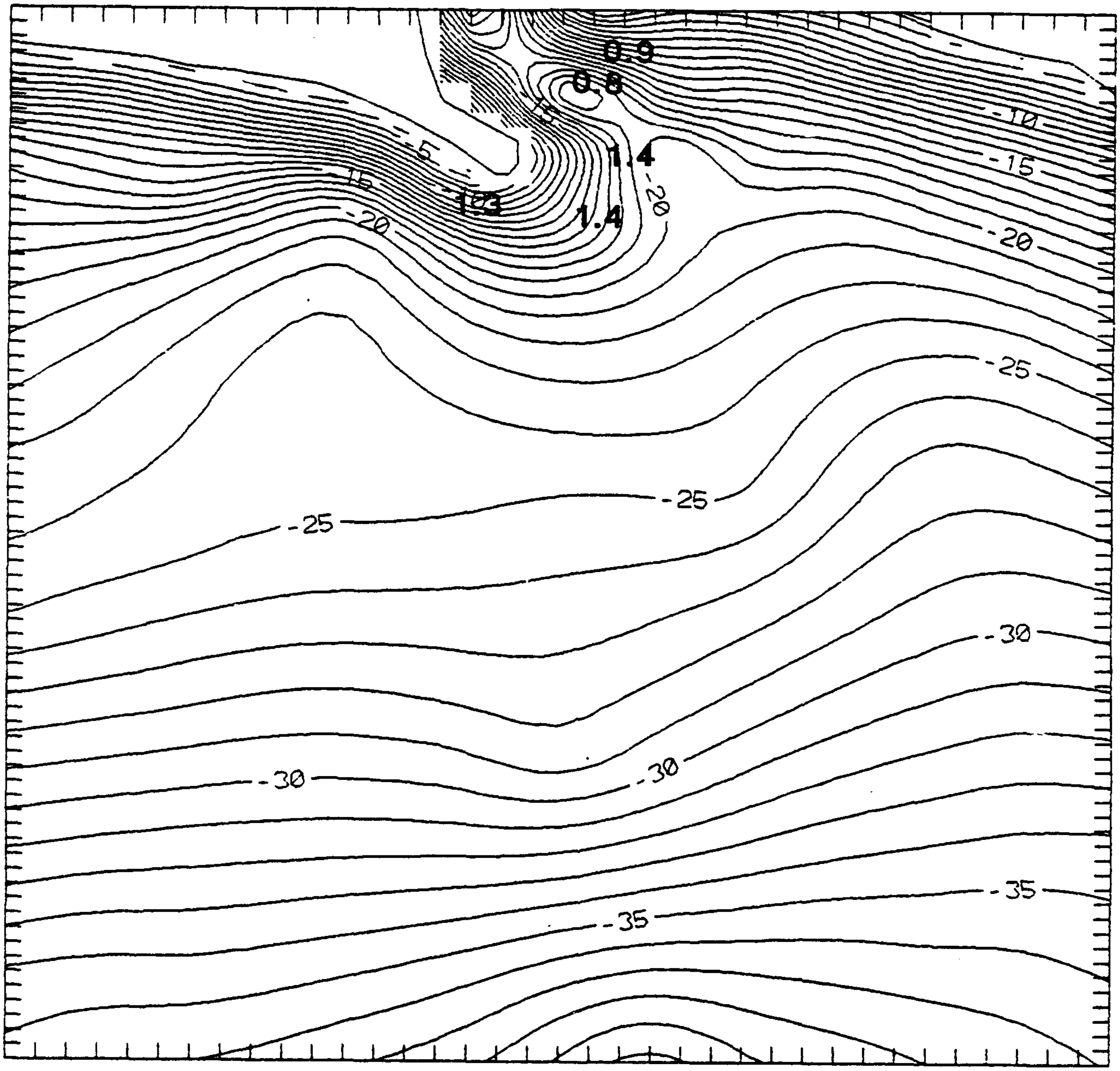
CHECKED: DATED

PLATE 5c



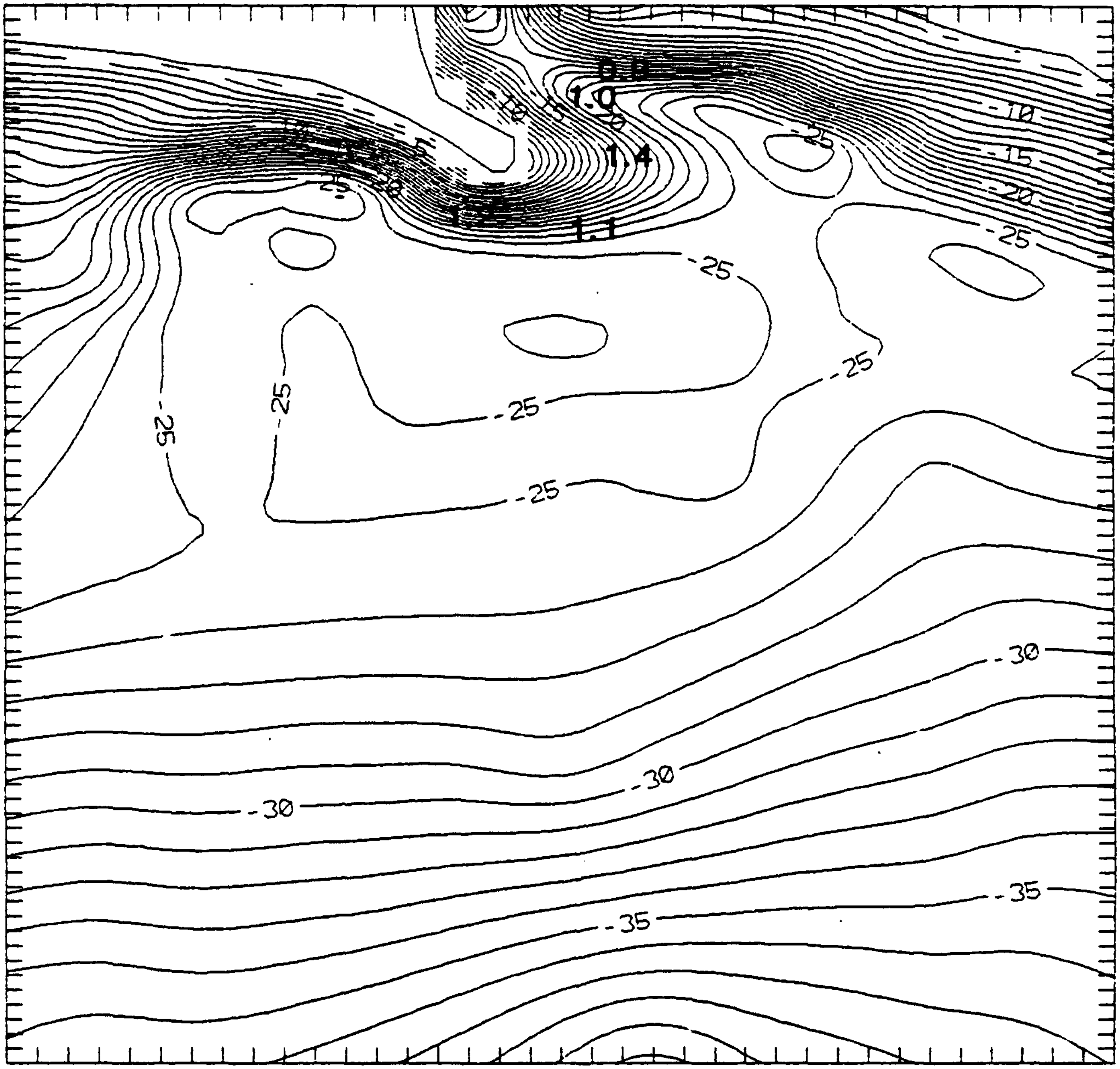
Wave Transformation Coefficients*
Post-Harbor Bathymetry, 17 sec Waves From 215°

* Includes Refraction, Diffraction & Shoaling from RCPWAVE.

SANTA CRUZ HARBOR
SHOALING STUDY

U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E

PLATE 5d



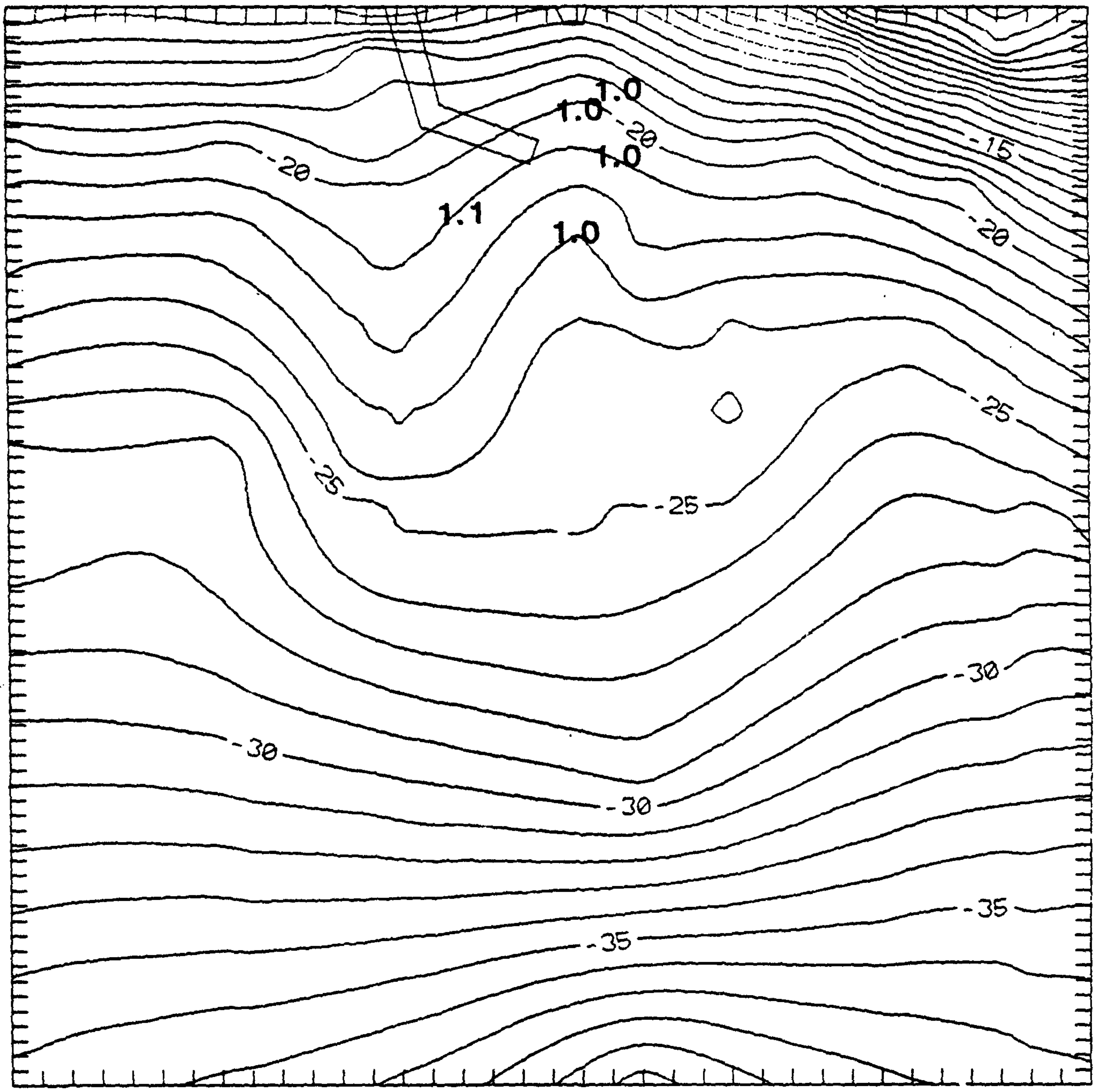
Wave Transformation Coefficients*
Offshore Sand Trap Bathymetry, 17 sec Waves From 215°

* Includes Refraction, Diffraction & Shoaling from RCPWAVE.

SANTA CRUZ HARBOR
SHOALING STUDY

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: DATED

PLATE 5e



Wave Transformation Coefficients*
Pre-Harbor Bathymetry, 10 sec Waves From 215°

* Includes Refraction, Diffraction & Shoaling from RCPWAVE.

SANTA CRUZ HARBOR
SHOALING STUDY

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: FILE NO.
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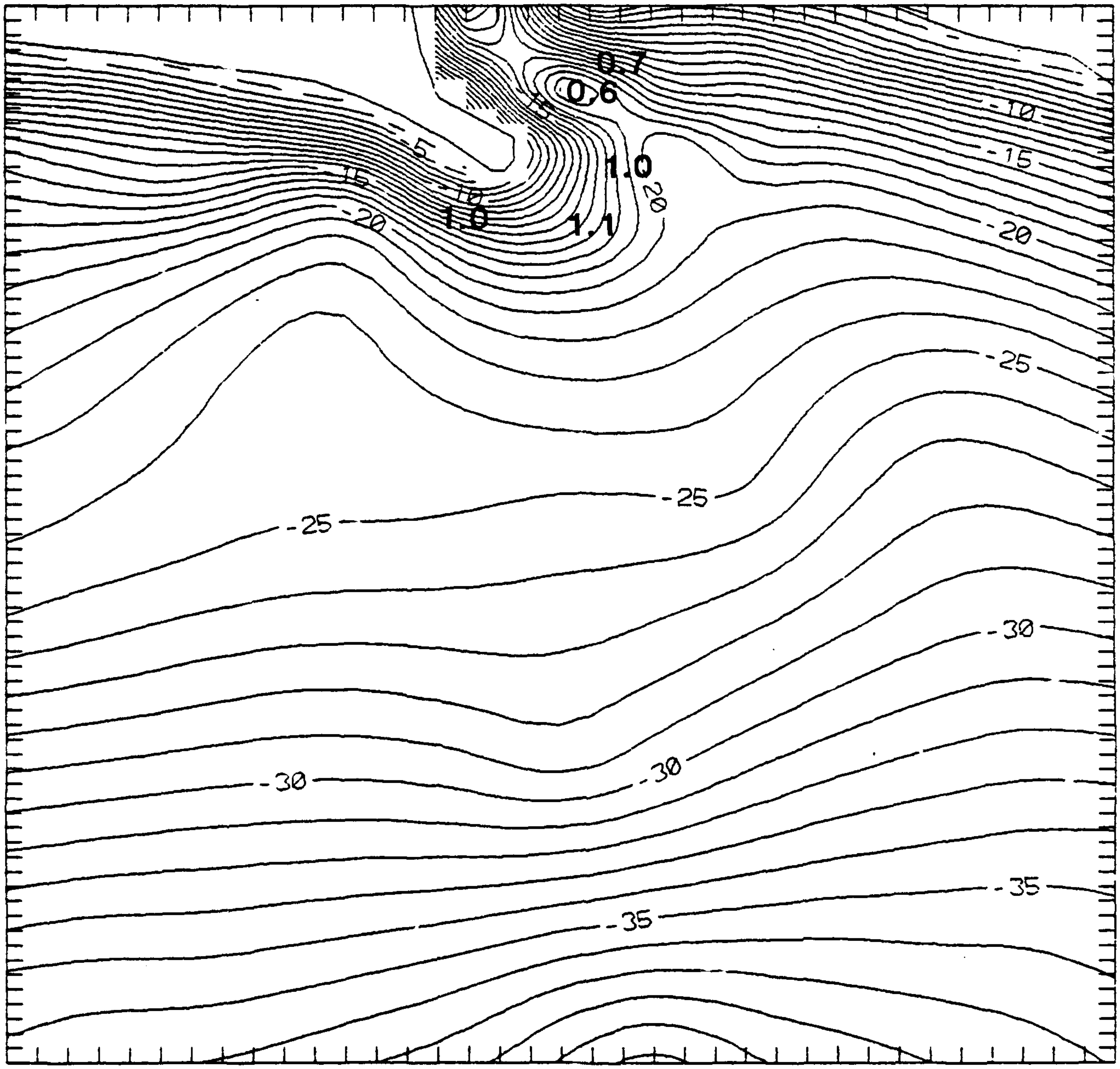

Wave Transformation Coefficients*
Post-Harbor Bathymetry, 10 sec Wave From 215°

*Includes Refraction, Diffraction & Shoaling from RCPWAVE.

SANTA CRUZ HARBOR
SHOALING STUDY

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E FILE NO.
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TRACED: TO ACCOMPANY REPORT
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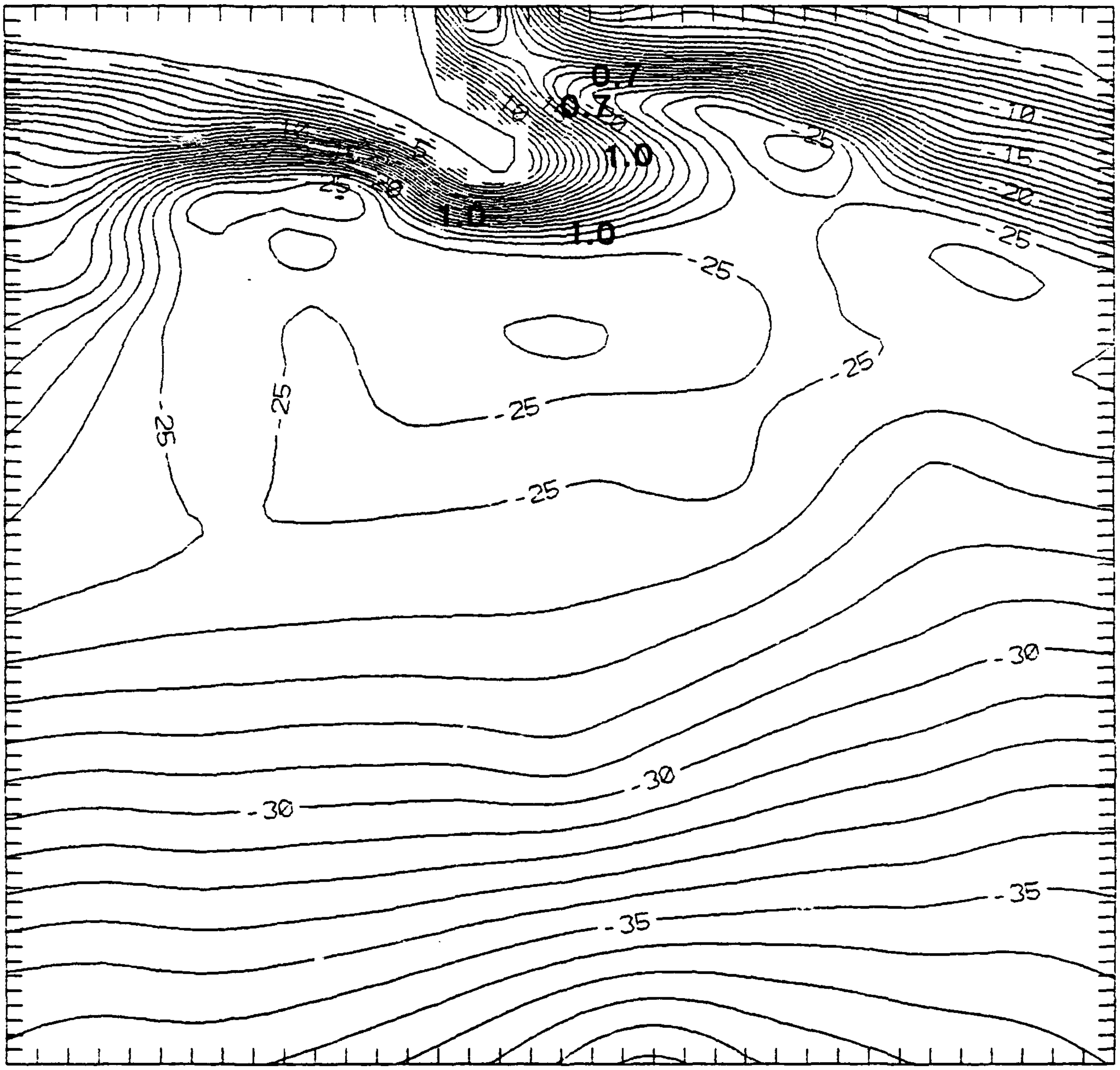
PLATE 5g



Wave Transformation Coefficients*
Offshore Sand Trap Bathymetry, 10 sec Waves From 215°

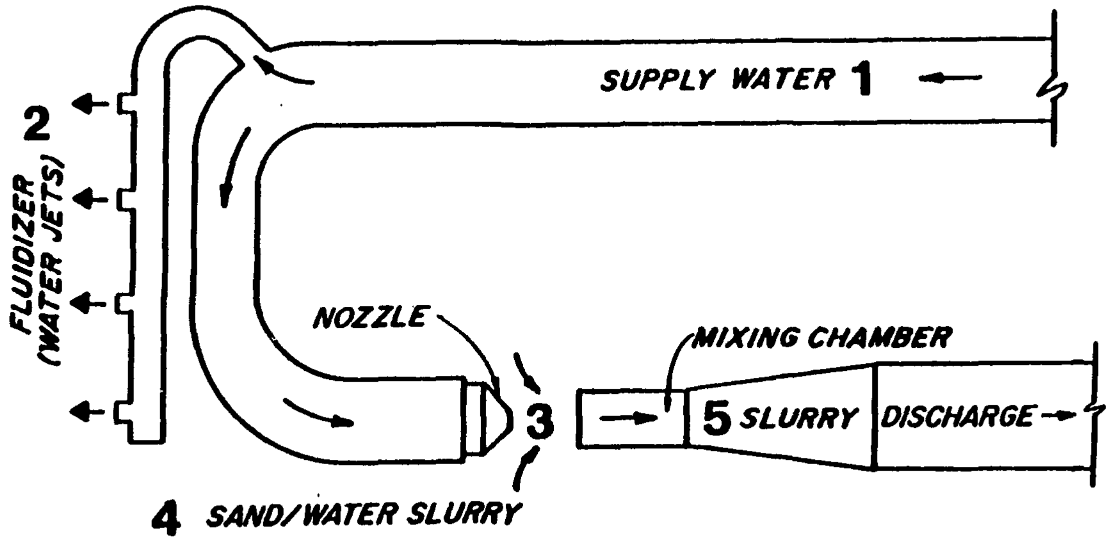
* Includes Refraction, Diffraction & Shoaling from RCPWAVE.

SANTA CRUZ HARBOR
SHOALING STUDY

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: DATED

PLATE 5n

1 WATER PUMPED TO EDUCTOR
2 JETS FLUIDIZE BEACH SAND
3 WATER FLOWS FROM NOZZLE TO MIXING CHAMBER
4 SLURRY DRAWN INTO MIXING CHAMBER
5 SLURRY FLOWS TO DISCHARGE

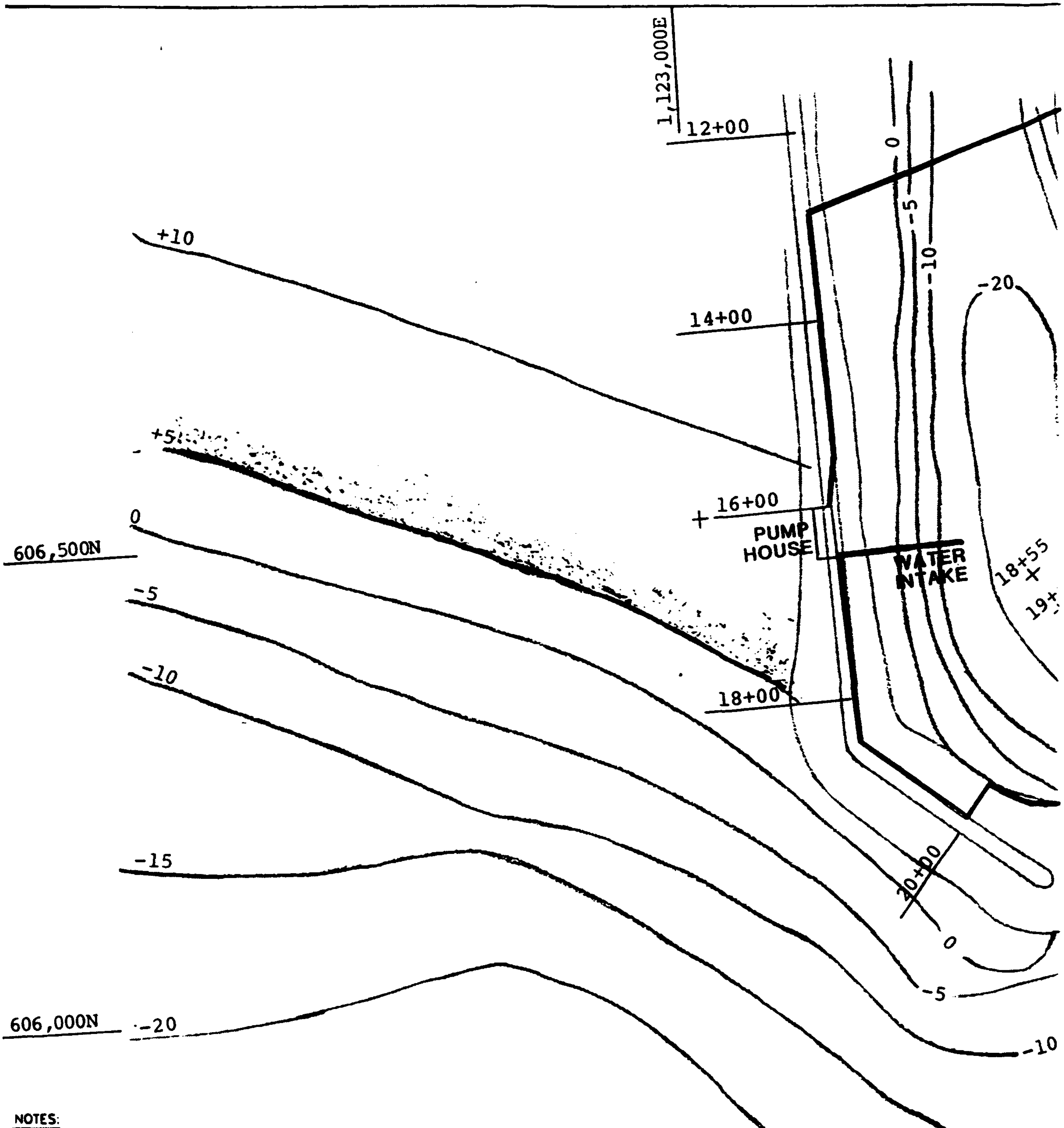


EDUCTOR

SANTA CRUZ HARBOR
SHOALING STUDY
FIXED JET PUMP
SAND BYPASS SYSTEM

U.S. ARMY ENGINEER DIST. SAN FRANCISCO C OF E
DRAWN FILE NO.
TRACED TO ACCOMPANY REPORT
CHECKED DATED
ALT. 6

PLATE 6a



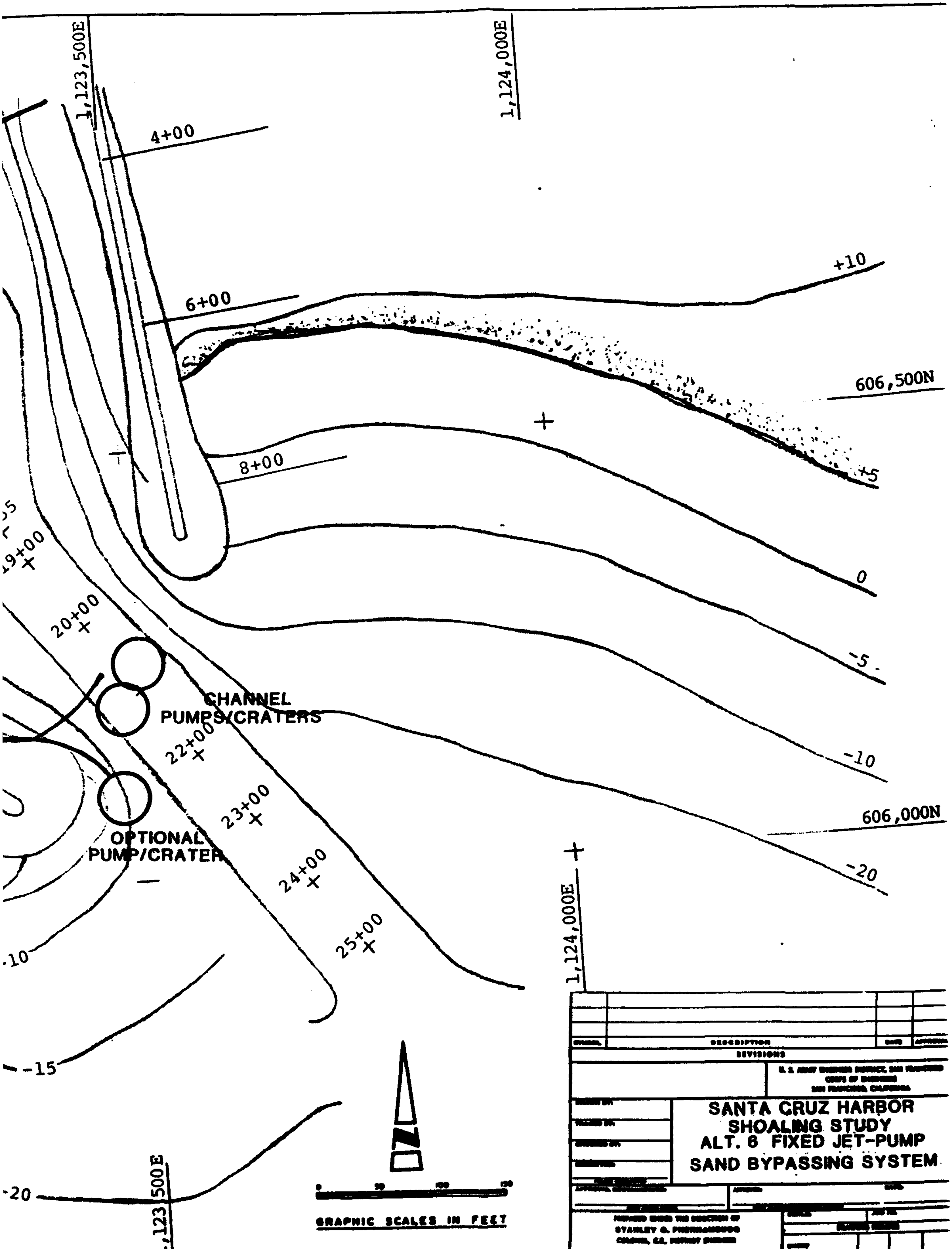
NOTES:

1. CHANNEL DEPTH CONTOURS REPRESENT TYPICAL POST DREDGE CONDITION AND APPROXIMATE NAVIGATION CHANNEL LIMITS BASED ON A REVIEW OF SURVEY DATA PROVIDED BY THE CORPS OF ENGINEERS AND SANTA CRUZ HARBOR DISTRICT.

2. NEARSHORE CONTOURS DEVELOPED FROM BEACH PROFILE SURVEYS BY GARY GRIGGS, ET AL. NOVEMBER, 1991.

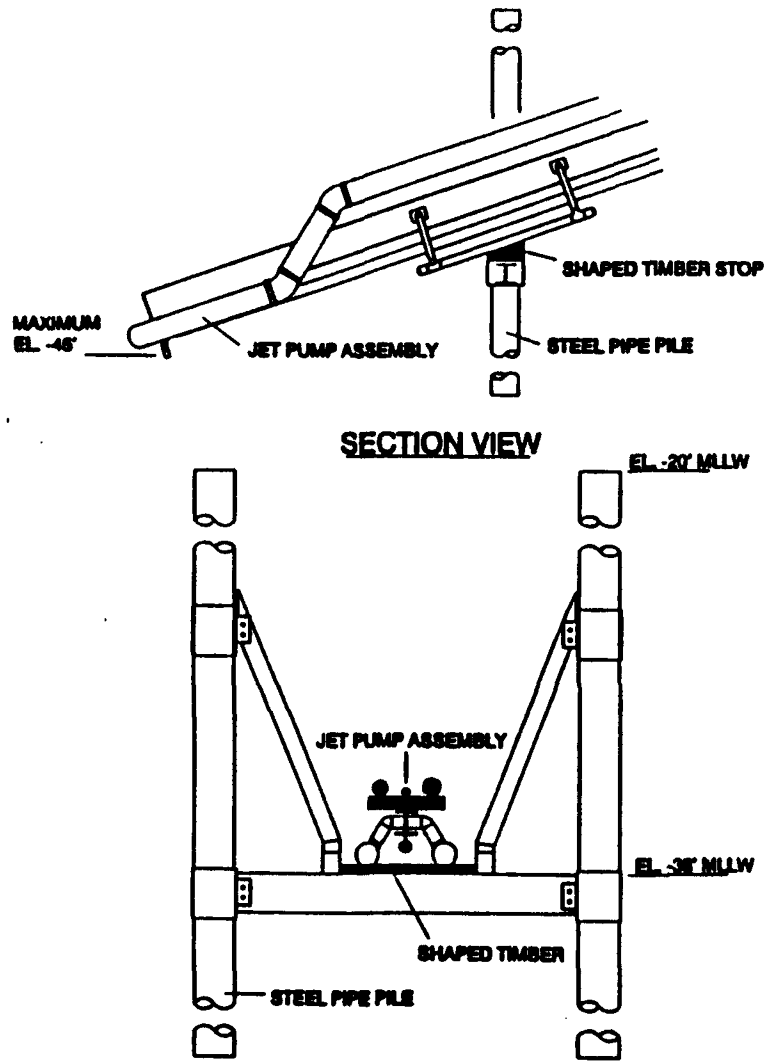
3. COORDINATES ARE REFERENCED TO CALIFORNIA COORDINATE SYSTEM AND WERE TAKEN FROM COE SURVEY DATED MAY 16-18, 1978.

4. ELEVATION REFERENCED TO MEAN LOWER LOW WATER DATUM.



1,123,500E
1,124,000E
4+00
6+00
8+00
+10
606,500N
+5
0
-5
-10
606,000N
-20
19+00
20+00
CHANNEL PUMPS/CRATERS
22+00
23+00
24+00
25+00
OPTIONAL PUMP/CRATER
-10
-15
-20
1,124,000E
1,123,500E
GRAPHIC SCALES IN FEET
DESCRIPTION
REVISIONS
SANTA CRUZ HARBOR
SHOALING STUDY
ALT. 6 FIXED JET-PUMP
SAND BYPASSING SYSTEM

PLATE 6b



FACING VIEW

STOP STRUCTURE DESIGNED TO LIMIT EXCAVATION DEPTH

(Patterson, Bisher, and Brodeen, 1991)

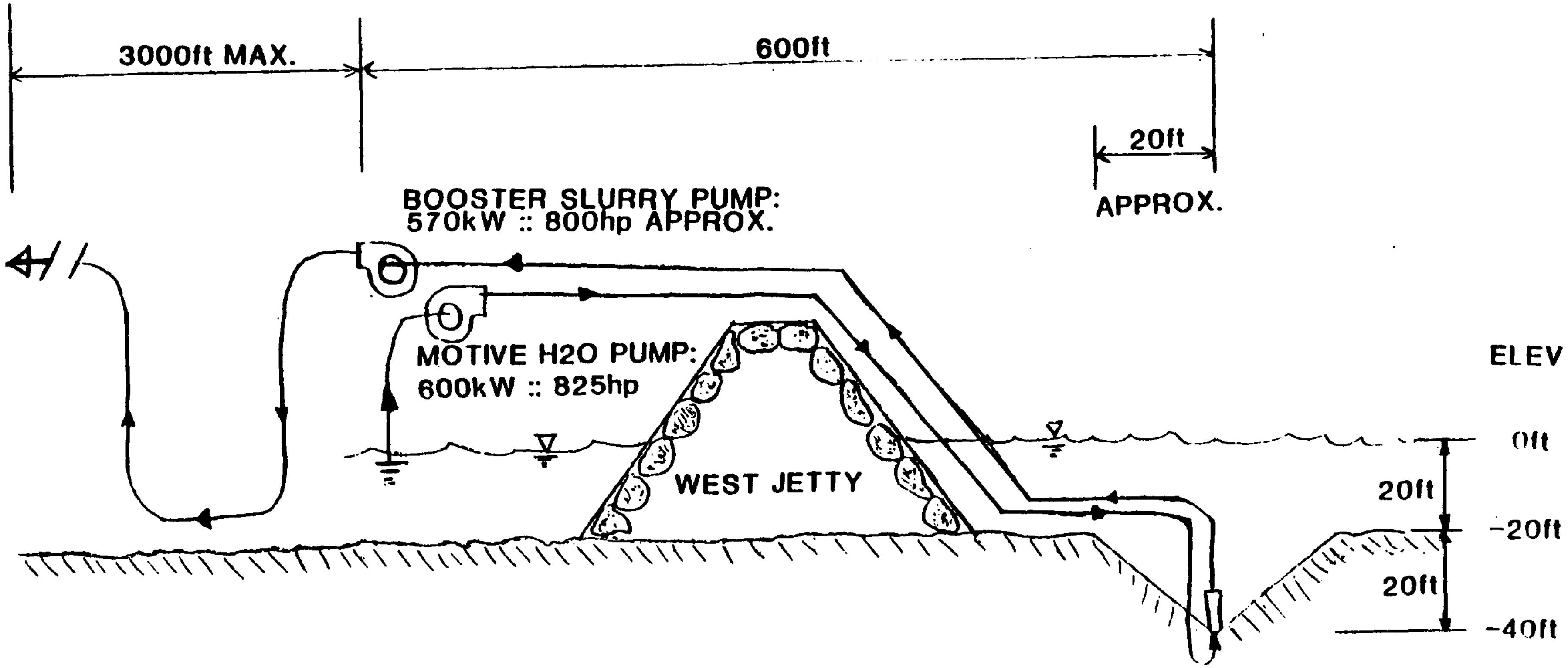
SANTA CRUZ HARBOR
SHOALING STUDY
FIXED JET PUMP
SAND BYPASS SYSTEM

U.S. ARMY ENGINEER DIST. SAN FRANCISCO C OF E
DRAWN FILE NO.
TRACED TO ACCOMPANY REPORT
CHECKED DATED
ALT. 6

SAND MOVEMENT

500cy in situ/hr X 1.4TONS/cy

700TONS/hr SAND



2 - JET PUMPS EACH IN CRATER APPROX.

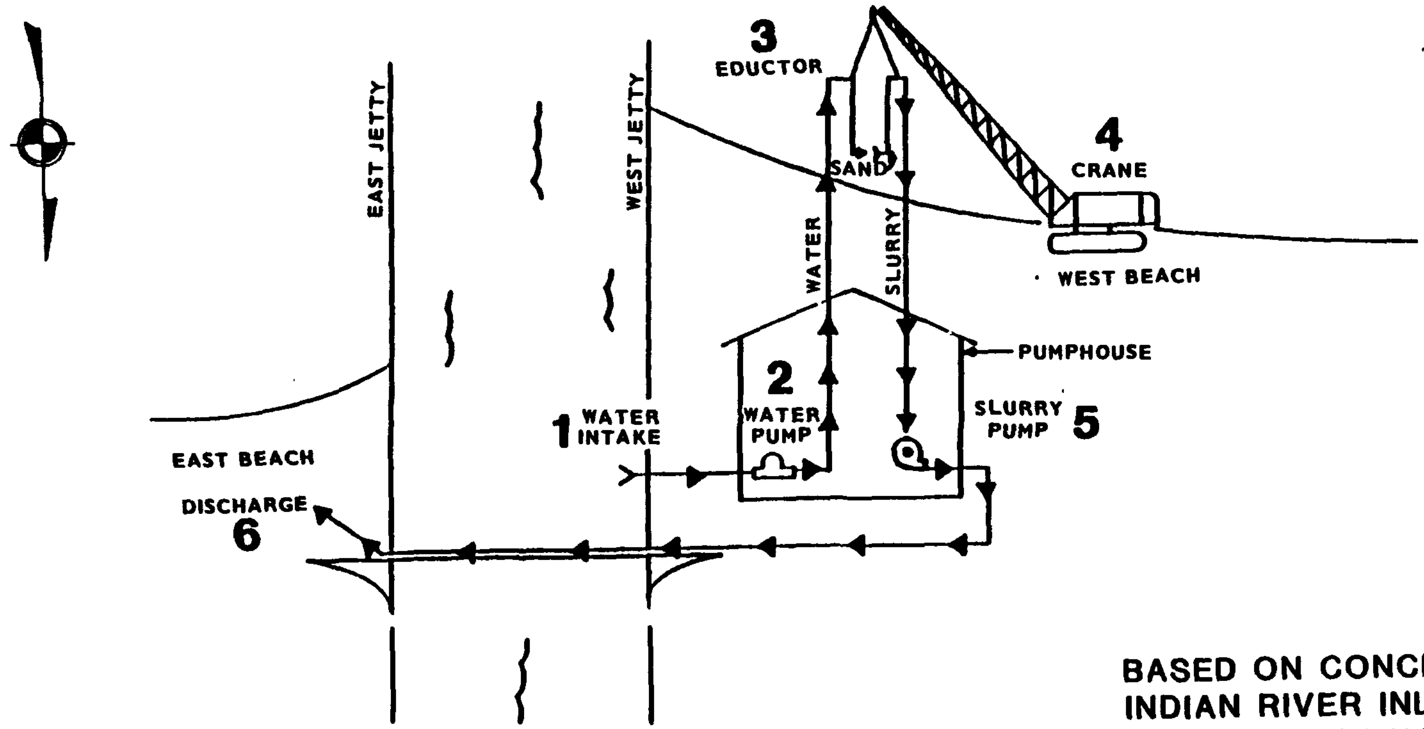
40ft - 60ft DIA. AT SEA FLOOR -20ft TYP.

SANTA CRUZ HARBOR
SHOALING STUDY
FIXED JET PUMP
SAND BYPASS SYSTEM

U.S. ARMY ENGINEER DIST. SAN FRANCISCO C OF E
DRAWN
TRACED
CHECKED
TO ACCOMPANY REPORT
DATED
FILE NO.
ALT. 6

PLATE 6d

1 WATER SUCTIONED FROM INLET
2 WATER PUMPED TO EDUCTOR
3 EDUCTOR EXCAVATES SAND
4 CRANE DEPLOYS EDUCTOR
5 SLURRY RETURNS TO PUMP
6 SLURRY PUMPED AS FILL



BASED ON CONCEPT USED AT INDIAN RIVER INLET, DEL. SAND BYPASSING PLANT

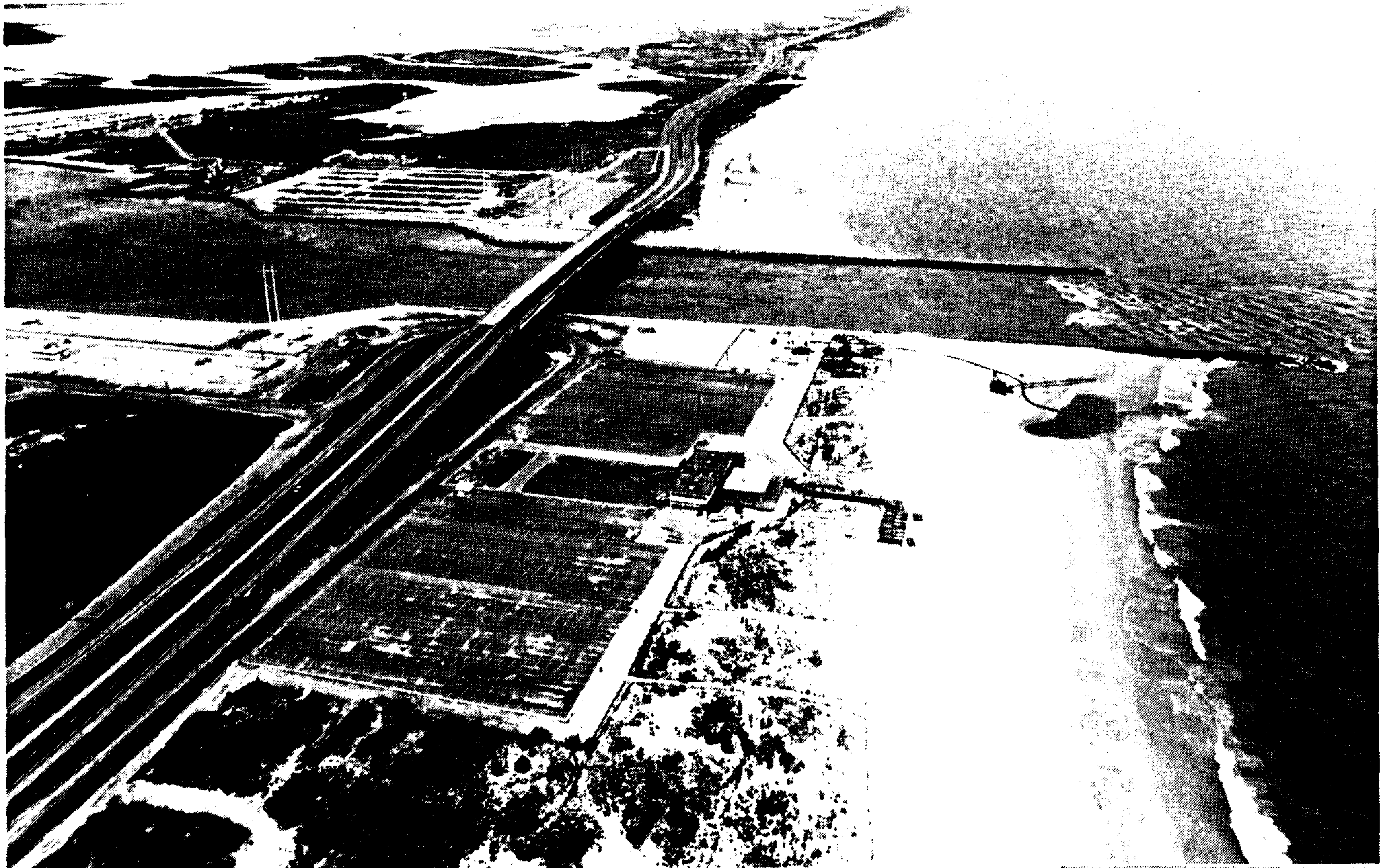
SANTA CRUZ HARBOR
SHOALING STUDY

MOBILE JET PUMP SYSTEM

U.S. ARMY ENGINEER DIST., SAN FRANCISCO C OF E
DRAWN
TRACED
CHECKED
TO ACCOMPANY REPORT
DATED

ALT. 7

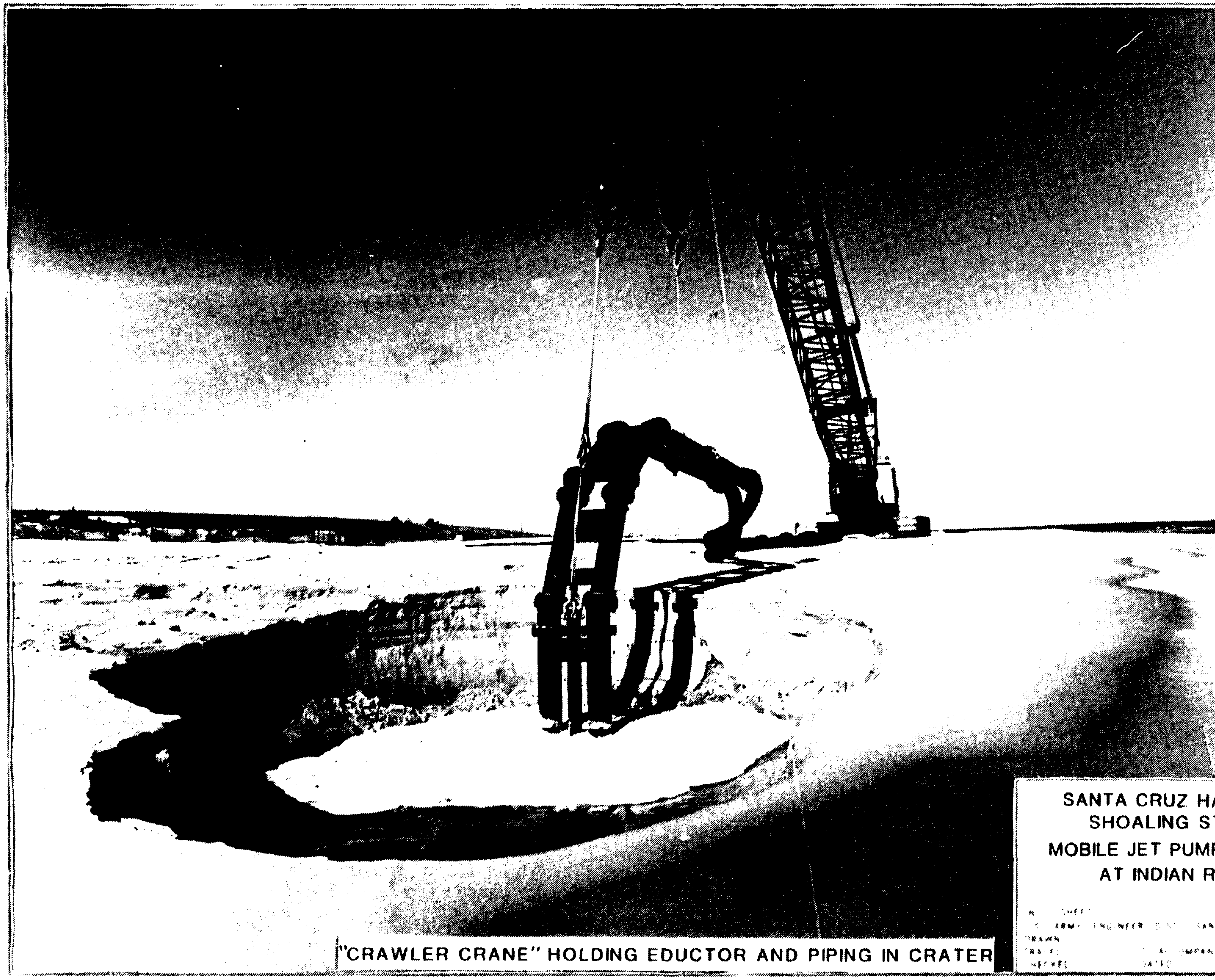
PLATE 7a



SANTA CRUZ HARBOR
SHOALING STUDY

MOBILE JET PUMP SYSTEM
AT INDIAN RIVER

PLATE 7b



"CRAWLER CRANE" HOLDING EDUCTOR AND PIPING IN CRATER

SANTA CRUZ HARBOR
SHOALING STUDY
MOBILE JET PUMP SYSTEM
AT INDIAN RIVER

PLATE 7c

APPENDICES

Appendix A, Pertinent Correspondence/Agreements

- A-1 Cost-Sharing Agreement for Dredge <u>Seabright</u>
- A-2 1984 COE Memos on ASA (CW) Meeting
- A-3 COE response to 6 March 92 Port Director Letter
- A-4 6 March 92 Port Director Letter requesting COE O&M Funding of Feasibility Studies and West Shoal Solutions
- A-5 30 January 92 Bill Lee Letter describing 1987 Harbor Entrance Accident
- A-6 14 November 91 Harbor Master Letter regarding Proposed Alternatives
- A-7 Congressional Letter Supporting 1992 Authorization for East Jetty Sealing

Appendix B, Sediment Budget and Surge Study

Appendix C, Environmental Assessment

Appendix D, Social Environment Study

Appendix E, Geotechnical Study

Appendix F, Primary Alternative Cost Estimates

Appendix G, Real Estate Cost Estimates

Appendix A, Pertinent Correspondence/Agreements

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A-1

Cost-Sharing Agreement for Dredge *Seabright*

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
630 Sansome Street, Room 720
San Francisco, California 94111-2206

REPLY TO
ATTENTION OF:
SPDOC

8 April 1986

SUBJECT: Santa Cruz, California, Harbor Maintenance

Commander, San Francisco District
211 Main Street
San Francisco, CA 94105-1905

1. Reference: SPDOC letter dated 6 November 84 and Endorsements 1 thru 7, subject as above.

2. On April 1984 we received two copies of the Cooperative Agreement with the Santa Cruz Port District which you finalized following the guidance of the 6th Endorsement, referenced above. These agreements were forwarded to the Assistant Secretary of Army, thru DAEN-CWB-W, for signature.

3. Both copies of the Agreement were signed by Mr. Robert K. Dawson on 3 April 1986. One copy was retained by Dawson's Office. The attached copy is for the Port's records. Conformed copies may be made for the District's file prior to distribution. The District may begin implementation of the agreement.

FOR THE COMMANDER:

Clark J. Hulce

CLARK J. HULCE
Assistant Division Counsel

Encl
Cooperating Agreement

COOPERATIVE AGREEMENT

BETWEEN

THE DEPARTMENT OF THE ARMY

AND

THE SANTA CRUZ PORT DISTRICT

Parties:

This Agreement is entered into this 2nd day of APRIL, 1986, by and between the Department of the Army, hereinafter called the Government, acting by and through the Assistant Secretary of the Army for Civil Works, and the Santa Cruz Port District, Santa Cruz, California.

Purpose:

The purpose of this Agreement is to complete the authorized construction at the federal project for Santa Cruz Harbor and to define the responsibilities of the parties for its future maintenance.

Authorities:

(a) The federal project for Santa Cruz Harbor was authorized by Section 101 of the River and Harbor Act of 1958 (72 Stat. 297) in accordance with the plans and subject to the conditions recommended by the Chief of Engineers in House Document No. 85-357.

(b) The Santa Cruz Port District is authorized by Section 20755 of the California Public Contract Code and by a resolution duly passed by its Board of Directors on Jan 28, 1986, to provide the nonfederal cooperation required by this Cooperative Agreement.

(c) This Cooperative Agreement is authorized by 31 U.S.C. §6305.

Background:

(a) The federal project for Santa Cruz Harbor was authorized in accordance with the Chief of Engineers' recommendation of the following requirements of nonfederal cooperation (among others):

> contribute in cash 35.1 percent of the first cost of jetties, channels, and the turning basin;
>
> contribute in cash 35.1 percent of the first cost of the sand bypassing plant and appurtenances; maintain the entire project except the jetties and dredged depths in the entrance channel, the inner channel, and the turning basin; and
>
> upon commencement of sand bypassing, assume operation and maintenance of the sand bypassing plant, make replacements thereto, and maintain the dredged depths in the entrance channel, the inner harbor channel, and the turning basin with the understanding that the United States will reimburse local interests for the actual cost of plant operation, maintenance, and replacement up to a limit of $35,000 annually.

(b) After several failures of experimental sand bypassing systems, the parties believe that a proper dredge would be the best type of plant for bypassing sand at the harbor.

(c) The Government desires to transfer its responsibility to maintain dredged depths in the entrance channel, the inner channel, and the turning basin to the Port District.

(d) The Port District is willing to accept the responsibility to maintain dredged depths in these areas if the Government will contribute the current capitalized value of the authorized annual $35,000 contribution plus the Government's 64.9 percent share of the first cost of a new dredge and appurtenant equipment and if the Government will provide technical advice in the acquisition of the dredge and appurtenant equipment.

NOW, THEREFORE, the parties agree as follows:

ARTICLE I - Responsibilities of the Santa Cruz Port District:

(a) Acquire, operate, maintain, and rehabilitate or replace a dredge and appurtenant equipment suitable for maintaining the dredged depths authorized by Congress in the entrance channel, the inner harbor channel, and the turning basin. Subject to Article I(n), below, the Port District will assume responsibility for maintaining the dredged depth of the entrance channel, the harbor channel, and the turning basin authorized by Congress.

(b) Prepare plans and specifications for the dredge and appurtenant equipment in a manner designed to promote full and open competition and requiring only the minimum actual needs of the federal project.

(c) Comply with the minimum wage and maximum hours provisions of the Fair Labor Standards Act, 29 U.S.C. §§201-219, as they apply to state and local government employees who are not employed

in integral operations in areas of traditional governmental functions.

(d) Comply with standards for environmental quality control that may be prescribed pursuant to responsibilities of the Federal Government under the National Environmental Policy Act of 1969, 42 U.S.C. §§4321-4335.

(e) Comply with the "Copeland Anti-Kickback Act," 18 U.S.C. §874, which provides that each contractor or subcontractor shall be prohibited from inducing, by any means, any person employed in the construction, completion, or repair of public work, to give up any part of the compensation to which he or she is otherwise entitled. The Port District shall report all suspected or reported violations to the U.S. Army Corps of Engineers.

(f) Comply with the Contract Work Hours and Safety Standards Act, 40 U.S.C. §§327-332, for contracts that involve the employment of mechanics or laborers.

(g) Assist the U.S. Army Corps of Engineers in its evaluation of the disposal of dredged material under 33 C.F.R. §209.145 if dredged material is disposed of in navigable waters or transported for the purpose of dumping it in ocean waters.

(h) Comply with Executive Order 11246 (30 Fed. Reg. 12319 and 12935) as amended by Executive Order 12086 (43 Fed. Reg. 46501), entitled "Equal Employment Opportunity" and as implemented in Department of Labor regulations (41 C.F.R. Chapter 60). This requires the inclusion of the equal opportunity clause prescribed in 41 C.F.R. §60-1.4(b) in all nonexempt contracts and subcontracts involving federally assisted construction. It applies to construction contracts which have or are expected to

have an aggregate value exceeding $10,000 within a 12 month period.

(i) Insure, pursuant to Executive Order 11738, that the facilities under its ownership, lease or supervision which shall be utilized in the accomplishment of the harbor maintenance are not listed on the Environmental Protection Agency (EPA) list of violating facilities, and notify the U.S. Army Corps of Engineers of the receipt of any communication from the Director of the EPA Office of Federal Activities indicating that a facility to be used in the project is under consideration for listing by the EPA.

(j) Establish safeguards to prohibit employees from using their positions for a purpose that is or gives the appearance of being motivated by a desire for private gain for themselves or others, particularly those with whom they have family, business, or other ties.

(k) Give the United States Army and the Comptroller General, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to this Cooperative Agreement, including the records of contractors and subcontractors performing under the Cooperative Agreement, and assure that such materials are reasonably available for examination, audit, or reproduction until three years after the final payment under this Cooperative Agreement. Audits of the Port District will be performed by the United States as required by OMB Circular A-128, 50 Fed. Reg. 19114 (May 6, 1985). Revised OMB Circular A-87, "Cost Principles for State and Local Governments," will apply.

(l) Have sufficient funds available to meet the non-federal share of the cost of acquiring the dredge and appurtenant equipment.

(m) Have sufficient funds available when construction is completed and at all times thereafter to assure effective operation and maintenance of the dredge and appurtenant equipment.

(n) The Port District reserves the right to refrain from dredging whenever it determines that it is operationally unsafe or economically infeasible to do so.

(o) On June 30 each year, inform the Corps of Engineers in writing of the amount of dredging done under this Agreement during the preceding 12 months.

(p) Not dispose of or encumber its title to the dredge without the written permission of the Assistant Secretary of the Army for Civil Works. Permission for the Port District's refinancing or replacement of the dredge shall not be unreasonably withheld or delayed by the Army. The Port District's initial financing, if any, of the dredge shall not be subject to this paragraph and shall not require the consent of the Assistant Secretary.

(q) Cause work on the dredge to be commenced within a reasonable time after receipt of notification from the District Engineer that funds have been approved, and prosecute the work to completion with reasonable diligence.

(r) Hold and save the United States free from damages due to the construction and maintenance of the project, except for damages due to the negligence of the United States.

John said
reference this:

ARTICLE II - Responsibilities of the Government:

(a) Contribute the authorized 64.9 percent share of the first cost of the dredge and appurtenant equipment. → Go to last page

(b) Contribute, in addition, the sum of $389,662.00, which is equal to the present worth of the $35,000 annual federal operation and maintenance contribution, computed for the remaining useful life of the federal project and discounted using the current 15 year Treasury bond market rate of 7.8 percent.

(c) Provide advice and assistance to the Port District during the design, procurement, testing, and acceptance of the dredge and appurtenant equipment. The U. S. Army Corps of Engineers will provide technical advice on the plans and specifications for the dredge and appurtenant equipment before bids are solicited and, again, before any modification of the plans or specifications is issued. By providing this technical advice, the Government does not warrant the suitability of the dredge and appurtenant equipment for the project.

(d) Continue to maintain the existing jetties at the federal project.

(e) Release to the Port District, upon the signing of this Cooperative Agreement by both parties, all funds currently held in escrow for the federal project.

ARTICLE III - Terms of Payment:

(a) At the time the contract to purchase the dredge is awarded by the Port District, the Government will pay $389,662.00 (the present worth of the $35,000 annual federal contribution, calculated as described above) to the Port District in a lump sum.

(b) Beginning on the date the contract to purchase the dredge is awarded, the Port District will provide a quarterly estimate of its expenditures for the first cost of the dredge and appurtenant equipment during the ensuing quarter. The Government will pay 64.9 percent of the estimated amount to the Port District each quarter upon receipt of the estimate. Upon delivery of the dredge and completion of a 180 day trial period, a final payment will be made by the Government or by the Port District to reflect the parties' proportionate shares of their actual expenditures under this Cooperative Agreement.

(c) The term "first cost," as used in this Agreement, means the initial capital cost of the dredge and appurtenant equipment including engineering, design, supervision, administration, construction and sea trials. It includes the costs incurred by both parties for such activities.

ARTICLE IV - General Agreements:

(a) During a one hundred and eighty day period of sea trials following the delivery of the dredge, it may become evident to both parties that deficiencies exist in the bypass system. With the concurrence of the Government, the Port District shall have the right to take action to correct such deficiencies. If

agreeable to the Government, the additional and/or corrective equipment will be funded under the cost sharing arrangement authorized by Congress for the first cost of the bypass system (i.e., Government bears 64.9 percent of such cost). The Port District shall be responsible for all maintenance dredging of the authorized Federal project beginning 60 days after delivery of the dredge, unless extended by the Government.

(b) The total cost of the dredge and appurtenant equipment purchased under this Cooperative Agreement shall not exceed $3,500,000, or in the event that the total estimated cost exceeds this limit, the Chief of Engineers, U.S. Army, will recommend to the Assistant Secretary of the Army for Civil Works whether to proceed with the acquisition of the dredge.

(c) The dredge shall not be used outside the boundaries of the Santa Cruz Port District without the written consent of the Assistant Secretary of the Army for Civil Works.

(d) Nonfederal cooperation requirements other than those specifically modified by this Cooperative Agreement remain unchanged. This Agreement is subject to any future legislation which would be inconsistent with the terms of the Agreement, and it also is subject to the appropriation and allotment of federal funds.

(e) This agreement is not intended to create any rights with respect to third parties, and shall create rights and obligations only with respect to the Port District and the Government.

(f) An estimate of the cost of the dredge and appurtenant equipment is attached as an exhibit to this Agreement.

(g) Except for the provisions of Article I(p), this Cooperative Agreement will terminate on July 1, 2013, unless the parties mutually agree to an earlier termination or to an extension.

FOR THE DEPARTMENT OF THE ARMY:

Robert K. Dawson
Assistant Secretary of the Army
for Civil Works

Date: 3 APR 1986

FOR THE SANTA CRUZ PORT DISTRICT:

Chairman

Date: April 2, 1986

A-2

1984 COE Memos on ASA (CW) Meeting

SPNFE-D 4 May 1984

MEMORANDUM FOR RECORD

SUBJECT: Santa Cruz Harbor, California - Results of Meeting between SPN & Santa Cruz Harbor Commission on 30 April 1984

1. BACKGROUND

a. On 6 April 1984 a meeting was held at Mr. Gianelli's office (ASA/CW) with attendees from Congressman Panetta's office, OCE, WRSC and the Santa Cruz Port Commission. Discussion results are summarized in Inclosure 1. At the meeting it was agreed that ASA/CW and the Corps of Engineers are committed to evaluate the Port District's five point proposal as listed in paragraph 2b of Inclosure 1.

b. On 13 April 1984 the Santa Cruz Port Commission met to devlop their position and formalize a "Memorandum of Understanding on a By-pass Plant for Santa Cruz Harbor," (an eight point proposal), which was transmitted in letter form, dated 16 April 1984, to Mr. Jim Wolfe, of SPN. This letter, Inclosure 2, was the basis for discussions between elements of SPN and the Port Commission on 30 April 1984 and is the primary reference of this Memorandum for Record.

c. Attendees at the 30 April 1984 discussions held at the Santa Cruz Port District Office were:

Jim Wolfe	SPN - Program Manager
Douglas Pirie	SPN - Project Manager
John Eft	SPN - Counsel
Brian Foss	Port District, General Manager
Alan Simpkins	Port District Commissioner
Bill Lee	Port District Commissioner

2. DISCUSSION - Keyed to Port District's Eight Point Proposal.

a. Proposal 1. Dredging System Procurement

"The Federal government, through the Army Corps of Engineers, will provide 80% of the cost of a dredging system to include:

- a suitable hydraulic dredge
- a suitable work boat
- pipe, anchors, cables and all anciliary equipment necessary to support a dredge
- ground equipment, including:
  round-terrain crane (15 ton)
  tractor for grading of beach
  fork lift (5-8 tons)
  a permanent disposal pipeline (as required by the California Coastal Commission)."

The Port District concluded that additional information was required before an appropriate list of required dredging systems components could be defined. The Port District is going to obtain the services of a dredging consultant to assist in refining their list of desired equipment. SPN's preliminary estimate of the minimum essential requirements is:

16" hydraulic dredge approx 1600 hp	$1,600,000
35 - 45' workboat, twin screw w/A-frame	150,000
16" plastic pipe, 4000 lf @ $18 w/connections	75,000
Angle, barge, steel pipe, pontoons & rigging	100,000
Front end loader, 2½ cu yd	105,000
	$2,030,000
+20% contingencies	406,000
	$2,436,000

b. The components necessary to effectively operate in the high wave climate of Santa Cruz during the winter must necessarily be of heavy duty construction. A dredge must be able to survive when confronted by 8-foot long period (12-20 second) swell and must be able to dredge between winter storms in seas of 4-6 feet with periods of 8-15 seconds. High freeboard splash boards, extra floatation, welded construction, and a heavy duty extra long ladder are some of the necessary aspects of equipment required at Santa Cruz. If the Port District is going to attempt to maintain navigability of the harbor entrance for all but 15 to 30 days per year, annual dredging quantities of 150,000 to 200,000 cubic yards should be expected. Between 1 May and 31 October 50,000 to 75,000 cubic yards would be available for dredging with the remainder to be handled during the stormy winter months.

c. The Port District requested an 80% Federal funding of the dredging system. It the cost of the system and necessary engineering, program management, component review activities, etc. were to approach the three million dollar level, the Federal funding percentage would most likely be closer to 75%. The basis for the Federal share percentage will be transmitted to the Port District to explain the method of computation.

d. Representatives of SPN and the Port District will meet again within the next few weeks to refine preliminary equipment estimates.

e. Proposal 2. Specifications

"The Port District will identify and select a system. The Corps of Engineers will review and make recommendations. Once the specifications are satisfactory to the Corps, the Port District will put the system out to bid. All costs of the design, selection, bidding, and acquisition will be part of the total system cost for purposes of compilation of cost-sharing amounts."

SPN legal counsel will investigate what is required to proceed with procurement. Otherwise, we agree with the Specifications proposal and SPN will involve SPD, WRSC, OCE, Philadephia District and SPN experts in dredge system design in our analysis of system requirements. The Port District requested names of unbiased dredging consultants to assist them in specifications and operations. Ogden Beeman and Thomas Turner were suggested as two consultants who were well known in the dredging community.

f. Proposal 3. Operations

"Once the system is operational, the Port District will operate and maintain it. Under this agreement, the Corps will not provide yearly operations and maintenance funds. The Port District reserves the right to request federal funds in the future if conditions so warrant."

This proposal is a major component of any agreement between the Corps of Engineers and the Santa Cruz Port District. SPN agrees to the proposal and it is understood that the Port District always has the right to request Federal funding. Upon acceptance of an operational sand bypassing system, the Port District will release the Corps of Engineers from operation and maintenance responsibilities with respect to the Santa Cruz Harbor channels and turning basin.

g. Proposal 4. Comprehensive Study

"While a harbor-based dredging system is the optimum solution at this time. Acknowledged short-comings exist with the jetty configurations. Comprehensive research and development is required to identify a state-of-the-art reconstruction. The Corps of Engineers will support the efforts of Congressman Panetta to change the 1958 harbor authorization in this regard. Such legislation would allow the Corps to perform such research and development as well as participate in a by-pass (dredge) acquisition."

If congressional authority and funding is provided to the Corps of Engineers to study any aspect of the Santa Cruz Harbor Project, the Corps of Engineers will conduct such studies as directed. Three elements of a suggested authorization were mentioned to the Port District as follows:

1. Determine if reconfiguration of the existing jetties or additional structures are necessary or desirable to increase the navigability of the Santa Cruz Harbor entrance.

2. Determine if sealing (grouting) the East Jetty is economically justifiable.

3. Determine the feasibility of constructing a fixed sand bypassing system at Santa Cruz Harbor. If the fixed sand bypassing system is technically and economically feasible, design a system for the Port District to include plans and specifications.

h. With respect to the Comprehensive Study Proposal, a philosophical question must be addressed by the Port District. The harbor entrance channel and jetty structures could be modified and maintained <u>at great expense</u> to provide all weather, 365 day per year navigability. However, is this a reasonable goal for which to strive in light of the actual needs of the harbor's users? Serious consideration should be given to defining the Port District's requirements. These thoughts were presented during discussions concerning Proposal 4.

i. Proposal 5. Continuance of Federal Project Status.

"The jetties will continue to be property of and responsibility of the federal government as per the original 1958 authorization."

This proposal was understood and agreed to.

j. Proposal 6. Jetty Sealing

"The Corps of Engineers will seal the east jetty in the manner in which the west jetty was sealed (Fall, 1983) either as part of the by-pass system or as a separate construction project."

Sealing the East Jetty should cost between $200,000 and $300,000 and would stop 5,000 to 10,000 cubic yards of sand from being annually pumped through the East Jetty shoaling the navigation channel. SPN will investigate our authority to accomplish this task. New legislation may be required. Preliminary economic evaluations support the desirability of sealing the East Jetty.

k. SPN's analysis of the East Jetty Sealing Proposal has pointed out two methods for construction. One method would be to flush the porous structure with water and inject a concrete grout curtain in the various layers of the structure above the core. A temporary steel sheet pile barrier on the beach side of the structure would preclude sand migration into the structure during flushing and grouting. The other method of sealing the East Jetty would be new to the Pacific Coast. Injection of a chemical grout into the existing sanded matrix and sand-chemical grout injected into the open areas of the cap matrix to form a grout curtain could be tried. The use of chemical grouting could be an economic alternative to cement based grouting, however, the long term effects of ocean wave surge (pumping effects) on chemical grout in a sand matrix are unknown.

l. Proposal 7. Clearing of Accumulated Debris

"The Corps will provide for the clearing of accumulated solid debris in the entrance channel."

Prior to turning over the Santa Cruz Harbor Project's channels to the Port District, the Corps of Engineers must dredge the channels to project depth. If this requires the removal of debris from the channels, it is understood that this is a Federal responsibility. Under present authority the Port District must provide an acceptable disposal site for any dredge material.

m. Proposal 8. Untitled

"It is hoped that a dredging system could be provided by the fall of 1984, however if such cannot be accomplished, the Corps of Engineers will continue to provide contract dredging until a system is on line."

This concern was discussed and it was determined that a dredging system could be obtained, at the earliest, by fall of 1985. The Corps of Engineers is held to its existing operation and maintenance authority until the acceptance of a dredging system and channels dredged to project dimensions, by the Port District. Federal funding availability will influence the level of dredging during the winter of 1984-1985.

3. CONCLUSIONS/ACTION

a. Mr. Douglas Pirie, telephone (415) 974-0461, was appointed Project Manager for this work.

b. Members of SPN and the Port District will meet in May to refine equipment requirements.

SPNPE-D 4 May 1984
SUBJECT: Santa Cruz Harbor, California - Results of Meeting between SPN & Santa Cruz Harbor Commission on 30 April 1984

c. SPN will research the appropriate funding mechanism which will allow the Port to purchase the floating sand bypassing system with Federal funds.

d. SPN will refine cost sharing economics.

e. Port District personnel will contact Congressman Panetta's office with desires for: (1) new legislation authorizing the Corps to analyze modifications to the present structures and develop plans for a fixed sand bypassing system, and (2) Congressional support of funding to maintain the existing channel to project depth.

f. Upon completion of negotiations with SPN, the Port District will submit to SPN a resolution embodying all agreed upon terms and conditions. Subsequently SPN will request funding to prepare a post authorization change.

g. Port officials want to pursue all actions with dispatch, however, mindful of past technical problems they want assurance that any agreement with the Federal Government will fully satisfy their long term requirements. Therefore, they want to take a little extra time to obtain the services of their own consultant.

DOUGLAS M. PIRIE
Project Manager

Copy Furnished:

Santa Cruz Port District
Mr. Brain Foss, General Manager
135 5th Street
Santa Cruz, CA 95062

DEPARTMENT OF THE ARMY
WATER RESOURCES SUPPORT CENTER, CORPS OF ENGINEERS
KINGMAN BUILDING
FORT BELVOIR, VIRGINIA 22060

REPLY TO
ATTENTION OF:

10 APR 1984

WRSC-D

MEMORANDUM FOR RECORD

SUBJECT: Santa Cruz Dredging Problems

1. Background

a. Large-scale and rapid shoaling has occurred at the project for many years. The volumes and locations of the shoals are impossible to predict with any accuracy.

b. In 1972, a portable, light-duty 12" cutterhead dredge was delivered to the project and turned over to the Harbor District for operation. (The authorizing document provides for the acquisition of "sand bypassing plant" with 64.9 percent Federal financing and 35.1 percent local financing. The authorizing document also indicates the Federal cost "for the actual cost of plant operation, maintenance and replacement up to a limit of $35,000 annually . . . .)" The dredge was severely damaged during the first few days of operation. The Harbor District demanded their 35.1 percent of the cost returned and the chapter was closed as a failure.

c. During 1976-1977 an experimental jet eductor pump system was installed and operated by WES personnel. The test was a failure and again the Harbor District staff were understandably upset and critical of the Corps efforts.

d. During 1978-1981, a two year maintenance dredging contract was awarded to a dredging firm. This contract provided for two to four dredging operations per year as needed. Under this arrangement, the harbor was kept open and the locals were pleased because dredging was performed four times/year. (During this four year period, the harbor was open 331, 365, 305 and 330 days/year).

e. In 1979, the San Francisco District and SPD recommended to OCE that a 12" to 14" cutterhead dredge be acquired as a "sand bypassing plant". The Dir/CW, General Heiberg, disapproved this proposal after reviewing the events associated with the failure of the 12" cutterhead dredge acquired in 1972.

f. The Harbor District is now proposing the acquisition of a 12" to 16" cutterhead dredge at an estimated cost of $1.2 million. (Based on our 1972 experience, it seems clear that a 12" dredge hull will not do the job. The acquisition of a heavy duty 14" to 16" dredge, with a hull large enough to provide adequate sea-keeping characteristics, along with the discharge pipeline, anchoring system, Xmas tree arrangement and winches and a workboat will cost at least twice the Harbor District estimate and could easily be three to four times the Harbor District cost estimate of $1.2 million).

Col Lord: SPD

Incl 1

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SUBJECT: Santa Cruz Dredging Problems

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g. The Harbor District also proposes that the Corps undertake an R & D program to reduce the amount of sand and surf in the harbor area. The R & D effort was estimated to cost $600,000 and would include consideration of:

- Jetty reconfiguration.

- Localized buried pipeline bypass system.

h. Attached as Encl 1, is an SPDCO-R Fact Sheet which refers to the above events and provides other background information.

i. The project map is attached as Encl 2, and the project narrative description is attached as Encl 3.

j. Attached as Encl 4, is a tabulation of 1958 Authorization (H.D. 357) vs Public Law 95-269 provisions prepared by the Harbor Commission.

k. Attached as Encl 5, is a brochure prepared by the Harbor District "Testimony for Legislative Appropriation".

2. Discussion

a. At the request of the Harbor District a meeting was held with Mr. Gianelli in his office at 1030 hours on April 6, 1984. The attendees were as follows:

Dell Smith, Washington Lobbyist
Brian Foss, General Manager, Port of Santa Cruz
Bill Lee, Chairman Dredging Committee, Santa Cruz
Congressman Panetta's staffer, Ms. Gia Cincone
Mr. Gianelli, Mr. Dawson, General Wall, General Palladino, Colonel Kleb, and Mr. Norden

b. The five-point proposal of the Santa Cruz group was reviewed by the Santa Cruz representatives:

(1) A complete R & D program by the Corps to evaluate jetty configuration and/or a localized buried pipeline sand bypassing system. 100 percent Corps cost.

(2) Immediate purchase of a 12" to 16" hydraulic dredge and appurtenant equipment at an estimated cost of $1.2 million. 64.9 percent Federal and 35.1 percent locals.

(3) Changes to the existing legislation so that procurement of the dredge would not close out the Federal project but would allow cost sharing on alternatives to continue.

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(4) Debris removal from the harbor.

(5) Sealing of the East Jetty to minimize sand penetration.

c. General Wall reviewed the legislative provisions related to the Santa Cruz project and indicated the Corps estimate for a heavy-duty 16" cutterhead dredge would be in the range of $4 to $6 million.

d. Considerable discussion followed, during which the Santa Cruz people indicated a desire for the 64.9 percent Federal funds be provided for acquisition of the dredge, plus a legislative change which would provide for a significant increase in the $35,000 per year for O&M by the Corps after the dredge was acquired.

e. Mr. Gianelli indicated the following:

(1) The funding screws will tighten on recreational harbors and possibly end up as zero funding in several years.

(2) OMB looks favorably on plans which reduce or eliminate future O & M funding requirements. Therefore, Santa Cruz should buy the dredge so they can do anything they want with it, and release the Corps from any O & M commitment. Under this plan, (100 percent local cost), the Corps R & D effort would be the Federal contribution. Under this plan the Harbor Commission could use the dredge any place they wanted, including bidding on Corps maintenance dredging at other projects.

(3) After additional discussion, Mr. Gianelli proposed another plan:

(a) ASA/CW and the Corps would evaluate an increase in the Federal contribution of 64.9 percent for acquisition of a dredge, with the understanding the Corps will be freed of any future O & M obligation. Under this plan, the Corps would undertake an evaluation of alternative long-range solutions such as jetty sealing, jetty modifications, and alternative equipment options.

f. After seeing that Mr. Gianelli was firm in the plan outlined in the preceding paragraph, the locals agreed to work with the San Francisco District to determine whether a mutually acceptable plan of this sort could be worked out.

g. As the Santa Cruz Group was leaving, General Palladino indicated he would request technical assistance from the Dredging Division during the course of the San Francisco/Santa Cruz future discussions.

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WESC-D
SUBJECT: Santa Cruz Dredging Problems

3. Conclusions:

a. We are committed to evaluate the plan outline in paragraph 2e(3).

b. The size and configuration of the hull of the dredge is an essential factor to be considered. The sea-keeping capability of the hull and a Xmas tree type of operation will be key factors in the number of days/year the dredge can be worked.

c. The dredge should be operated only when very favorable wave conditions exist in order to avoid damage to the equipment.

d. Competent personnel must be employed to operate and maintain the dredge. This is also a critical factor.

e. A significant increase in the acquisition cost percentage can easily be justified under the provisions of the plan in paragraph 2e(3). For example, General Palladino said the Corps average cost for the past two years has been about $600,000 for dredging twice per year. (Our experience indicates that four dredging operations are needed to keep the channel open most of the year (see paragraph 1d). So, if we dredge four times per year, it is reasonable to expect the annual cost to be in the $1.0 to $1.2 million range).

(1) Assume the Corps paid 90 percent for a dredge that cost $5 million ($4.5 million) and the Corps was freed of any future O & M cost. Based on O & M costs of $600,000 per year and discounting inflation trends, in 7.5 years the Corps would not have any future commitment to maintain the project. Based on O & M cost of $1.1 million per year for maintenance to keep the channel open most of the year and the 90 percent Federal share of the acquisition cost ($4.5 million), the Corps would not have any future commitment to maintain the project after 4.1 years.

(2) Assume the Corps paid 80 percent for a dredge that cost $5 million ($4.0 million) and the Corps was freed of any future O & M costs. Based on O & M costs of $600,000 per year, in 6.7 years the Corps would not have any future commitment to maintain the project. Based on O & M costs of $1.1 million per year to keep the channel open most of the year and the 80 percent Federal share of the acquisition ($4 million) the Corps would not have any future commitment to maintain the project in 3.6 years.

f. If the acquisition cost of a suitable dredge should be, say $3 million, through the acquisition of suitable used equipment, the break even period would be 5 years ($600,000 O & M cost/year) or 2.7 years ($1.1 million O & M cost/year).

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WRSC-D
SUBJECT: Santa Cruz Dredging Problems

10 APR 1984

g. The Corps should make every effort to evaluate whether the acquisition of a suitable dredge, a reasonable plan for operation and maintenance of the dredge can be evolved, and the Corps freed of future O & M costs can be worked out with the Santa Cruz group.

W. R. MURDEN, P. E.
Chief, Dredging Division

5 Encl
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Copies Furnished:
DAEN-CWZ-C (Colonel Volpe)
DAEN-CWO-M (Mr. Mikel)
DAEN-CWB (Mr. Steinberg)
DAEN-CWP (Mr. Holiday)
DAEN-CWZ-W (Colonel Amrine)

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COE response to 6 March 92 Port Director Letter

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
211 MAIN STREET
SAN FRANCISCO, CALIFORNIA 94105 - 1905

April 2, 1992

Programs and Project
Management Division

Mr. Brian E. Foss
Port Director
Santa Cruz Port District
135 5th Avenue
Santa Cruz, California 95062

Dear Mr. Foss:

This responds to your March 6, 1992, letter regarding the study of Santa Cruz Harbor entrance problems.

Your letter is not accurate in describing the April 6, 1984, meeting between the Port District and the Corps of Engineers as an "agreement," binding on the Corps of Engineers. Also, your letter neglects to mention the April 2, 1986, cooperative agreement which was reached between the Port and the Corps, and which is binding on both parties. At the 1984 meeting, the Port presented a five point <u>proposal</u> to the Assistant Secretary, Mr. Gianelli. Two years of technical discussions and negotiation followed. Finally, a written cooperative <u>agreement</u> was signed by the Port and the new Assistant Secretary, Mr. Dawson. We must look to this final cooperative agreement to determine the obligations of the Port and the Corps.

The purpose of the 1986 cooperative agreement was stated explicitly in the agreement: "The purpose of this Agreement is to complete the authorized construction at the federal project for Santa Cruz Harbor and to define the responsibilities of the parties for its future maintenance." In Article I(a) of the cooperative agreement, the Port assumed responsibility for maintaining the dredged depth of the entrance channel, the harbor channel, and the turning basin authorized by Congress in 1958. Clearly, the complete assumption of this responsibility by the Port was the consideration for the Corps' agreement to contribute the cash value of its future O & M obligation under the 1958 Act. Therefore, we believe that the Corps has no current responsibility or authority to spend Corps O & M funds in the channel areas. Article IV(d) made the cooperative agreement subject to any future legislation which would be inconsistent with the terms of the agreement, but there has not, as yet, been any such legislation.

As to the maintenance of the jetties, our current study will address problems with the west jetty. The fact that the west jetty is significantly impounded with sand is not a matter of "maintenance" of the jetty in our opinion.

If you require any additional information on this matter, please call me at (415)744-3021 or contact the shoaling study Project Manager, Barney Opton, at (415) 744-3259. Mr. Tom Kendall, who is the technical manager and is preparing the Reconnaissance Report for the shoaling study, remains available to answer specific technical questions at (415) 744-3363.

Sincerely,

Stanley G. Phernambucq
Colonel, Corps of Engineers
District Engineer

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6 March 92 Port Director Letter requesting COE O&M Funding of Feasibility Studies and West Shoal Solutions

SANTA CRUZ
HARBOR

March 6, 1992

Col. Stanley G. Phernambucq
U S Army Corps of Engineers
211 Main Street
San Francisco, CA 94105

SUBJECT: Study of Santa Cruz Harbor Entrance Problems

Dear Col. Phernambucq:

As you know, the Corps is now conducting a reconnaissance study of the Santa Cruz Harbor entrance. This study is a product of a 1984 agreement between the Port District and then Secretary of Army Mr. William Gianelli. We believe that the agreement has been misinterpreted and we ask you to have it clarified.

FEASIBILITY FUNDING

Simply stated, we believe that the study of the entrance should be a Corps of Engineers O & M study and not a cost shared recon/feasibility process. Our reasoning follows.

~ The April 6, 1984 meeting was attended by the following people:
William Gianelli - Sec. for Civil Works
Robert Dawson - Deputy Sec. for Civil Works
Gen. John Wall - COE
Gen. Palladino - COE
Col. Kleb - COE
Bill Merdon - COE
Del Smith - Washington Rep. for Port District
Brian Foss - Port Director, Santa Cruz Port District
Bill Lee - Chairman, Port District Commission

~ At the meeting, a package of elements was agreed upon. These include:

~ Cost share of a dredge system as the only system that had "Reliability" and "Certainty". (Moffett & Nichol Santa Cruz Shoaling Study - 1978).

Santa Cruz Port District
135 5th Ave., Santa Cruz, CA 95062 (408) 475-6161

- Acknowledgement that a dredge, although a proven means of maintaining the channel would not solve the known hazards of breaking surf even when the channel was at depth.
- Acknowledgement that the dredge, although the only reliable and certain means of sand removal, could potentially be improved on by jet pump augmentation.
- Acknowledgement that the jetty system was not functioning at maximum effectiveness because it was impounded by sand to the west, and that some structural or operational changes might correct this problem.
- Acknowledgement that the aforementioned problems of surf and jetty configuration were inter-related.

These are consistent with our subsequent meeting with District personnel on April 30, 1984 and with our April 16, 1984 letter which had eight points of agreement.

In accepting a dredging system which the Port District knew was less than a total solution to the overall Santa Cruz Harbor problem, the District demanded and Mr. Gianelli agreed that a comprehensive study was a fair and appropriate accompaniment to the dredging system. As you know, Congressman Panetta sponsored subsequent legislation in the 1986 water authorization bill for that comprehensive study as well as for sealing of the east jetty.

We believe that the equities of the 1984 agreement point to a 100% Corps funded study (Reconnaissance and Feasibility). We believe that Congressman Panetta would concur with this analysis. The characterization of the "Comprehensive Study" as a 50/50 cost share reflects a lack of historical knowledge. We think, frankly, it is just an oversight. Bill Merdon's memorandum record of 10 April 1984 concludes (pg. 2, 3, 4) that a COE study was appropriate.

We ask that the office of the Chief of Engineers make a determination on the fairness and precedent for a 100% COE funded next phase of the study.

It is our view that the study should be concluded by the use of COE O & M funds.

JETTY MAINTENANCE

We believe that a major aspect of the harbor entrance problem has been overlooked. The 1958 authorization leaves the Corps of Engineers the total responsibility for jetty maintenance. (H.D. 357 1958 Congressional Record, excerpt attached). We believe that this includes not only jetty condition but jetty function. The fact is that the west jetty is now so impounded with sand that it does not function. What used to be a 1,200 foot barrier into the Monterey Bay is now effectively only 300+ feet.

While some impoundment was anticipated, and encouraged to protect upccast beaches, the massive shoal to the west of the harbor was not. We believe that the shoal is a Corps of Engineers O & M problem. It certainly has to be separate from the 1986 MOU concerning the conduct of the dredging operation. The west side shoal is outside the dredge's envelope of operation and outside the Port committment to maintain "dredged depths" (as per the MOU).

In summary, we believe the Corps of Engineers is responsible for studying and developing a solution to the west side shoal problem.

Sincerely,

Brian E. Foss
Port Director

BEF:jar
letter 17-19

85th Congress, 2d Session - - - - - House Document No. 357

SANTA CRUZ HARBOR, CALIF.

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED FEBRUARY 27, 1958, SUBMITTING INTERIM REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATION, ON A SURVEY OF SANTA CRUZ HARBOR, CALIF., AUTHORIZED BY THE RIVER AND HARBOR ACT APPROVED JULY 24, 1946

MARCH 25, 1958.—Referred to the Committee on Public Works and ordered to be printed with one illustration

UNITED STATES
GOVERNMENT PRINTING OFFICE
23396 WASHINGTON : 1958

LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY,
Washington, D. C., March 7, 1958.

THE SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am transmitting herewith a favorable interim report dated February 27, 1958, from the Chief of Engineers, Department of the Army, together with accompanying papers and illustration, on a survey of Santa Cruz Harbor, Calif., authorized by the River and Harbor Act approved July 24, 1946.

In accordance with section 1 of Public Law 14, 79th Congress, and Public Law 732, 79th Congress, the views of the Governor of the State of California and the Department of the Interior are set forth in the inclosed communications, together with the reply of the Acting Chief of Engineers to the Secretary of the Interior. The views of the Public Health Service are also inclosed.

The Bureau of the Budget advises that there is no objection to the submission of the proposed report to the Congress; however, it states that no commitment can be made at this time as to when any estimate of appropriation would be submitted for construction of the project, if authorized by the Congress, since this would be governed by the President's budgetary objectives as determined by the then prevailing fiscal situation. A copy of the letter from the Bureau of the Budget is inclosed.

Sincerely yours,

WILBER M. BRUCKER,
Secretary of the Army.

COMMENTS OF THE BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D. C., March 6, 1958.

The honorable the SECRETARY OF THE ARMY.

MY DEAR MR. SECRETARY: Assistant Secretary Short's letter of March 5, 1958, submits the proposed report of the Chief of Engineers on Santa Cruz Harbor, Calif., authorized by the River and Harbor Act approved July 24, 1946.

The Chief of Engineers recommends improvement of Santa Cruz Harbor to provide for a small-boat harbor in Woods Lagoon, consisting of an entrance channel 100 feet wide, 20 feet deep and 900 feet long, continuing 15 feet deep and the same width for a distance of 370 feet; an inner channel 15 feet deep, 150 feet wide, and 800 feet long, continuing 10 feet deep for an additional 600 feet; a turning basin 10 feet deep, 250 feet wide, and 300 feet long; an east jetty 810 feet long, and a west jetty 1,200 feet long; and a sand bypassing plant;

SANTA CRUZ HARBOR, CALIF.

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

DEPARTMENT OF THE ARMY,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 27, 1958.

Subject: Santa Cruz Harbor, Calif.
To: The Secretary of the Army.

1. I submit for transmission to Congress my interim report with accompanying papers on preliminary examination and survey of the coast of northern California from Point Pinos to the northern boundary of the State, including the San Francisco Bay area, with a view to the establishment of harbors for light-draft vessels, authorized by the River and Harbor Act approved July 24, 1946. This report considers Santa Cruz Harbor only. Reports on other harbors will be submitted later.

2. Santa Cruz Harbor is on the north shore of Monterey Bay about 65 miles south of the entrance to San Francisco Bay and 14 miles north of Moss Landing, the nearest small-boat harbor. San Lorenzo River flows through the city of Santa Cruz and empties into the harbor. The mean tidal range is 3.5 feet. There is no existing Federal project at Santa Cruz Harbor. In a recently completed beach-erosion report, the Chief of Engineers recommended Federal participation in beach protection in the area under consideration in this report. Local interests have constructed 2 piers in the harbor: 1, a private recreational pier extending 500 feet from shoreline to the 10-foot contour in the bay, and the other, a municipal wharf, extending 2,732 feet to the 32-foot contour.

3. The area tributary to Santa Cruz Harbor for recreational small-boat purposes includes all or parts of 10 nearby counties having a total population in 1950 of over 1 million. The coastal areas are developed predominantly for resort and recreational purposes while the interior areas are devoted principally to agriculture and the processing of agricultural products. The city of Santa Cruz, which had a permanent population of 22,794 in 1955, has on weekends about 45,000 during the winter and 100,000 during the summer vacation period. Seventy commercial fishing craft and seven sport-fishing vessels operate out of Santa Cruz Harbor during the summer. The commercial fish catch marketed at Santa Cruz in 1954 amounted to 1,223 tons, valued at $207,580. There are no fish canneries in Santa Cruz and all fish are either iced and shipped elsewhere or retailed locally.

4. Local interests desire a protected small-boat harbor at Santa Cruz to serve the existing fishing fleet and prospective recreational craft on a year-round basis. They suggest that Woods Lagoon, a low area behind the Twin Lakes beach about 0.5 mile east of the mouth of San Lorenzo River, be improved northward to the Southern Pacific Railroad for the harbor and that parallel rubble-stone jetties

be provided to protect the entrance channel in the bay. In support of the project, local interests state that Santa Cruz is the foremost seaside resort in the highly developed coastal recreational area of northern California where sports fishing and boating are available during the summer months. However, these pursuits are limited because the sole means of protecting craft in the harbor from storms is by hoisting them onto the municipal pier by means of 1-ton davits located on the pier. Accordingly, the majority of boats using the Santa Cruz Harbor must be berthed at Moss Landing and Monterey Harbor, 25 miles south, from October through April. In addition, they state that during the storm season there are many extended fair-weather periods during which sports and commercial fishing could be carried on if a protected harbor were available at Santa Cruz. They further state that a protected harbor at Santa Cruz would be a harbor or refuge for local and transient recreational and fishing craft. Local interests have expressed willingness to cooperate in the desired improvement.

5. The district engineer finds that the most suitable plan for a small-boat harbor at Santa Cruz would provide for the improvement of Woods Lagoon, near the eastern boundary of the city, consisting of an entrance channel 100 feet wide, 20 feet deep, and 900 feet long, continuing 15 feet deep with the same width for an additional 370 feet; an inner harbor channel 15 feet deep, 150 feet wide, and 800 feet long, and continuing 10 feet deep for an additional 600 feet; a turning basin 10 feet deep, 250 feet wide, and 300 feet long; an east jetty 810 feet long; a west jetty 1,200 feet long; and a sand bypassing plant if needed. The plan would provide berthing space for 260 recreational craft and mooring space in the turning basin for the fishing fleet. The site has sufficient area to provide slips for the number of boats expected to use the harbor together with necessary service facilities. The dredge spoil is suitable for deposition behind bulkheads to be constructed by local interests and for needed maintenance of adjacent beaches. The plan, which would require the relocation of East Cliff Drive, would be adaptable to expansion in Woods Lagoon above the Southern Pacific Railroad when and if it becomes necessary. The district engineer has determined that the harbor jetties would interrupt the normal downcoast movement of littoral drift. Since the effect of such an interruption on the harbor channels and on the downcoast beaches can be determined only after the jetties are constructed, he proposes that initial channel maintenance be accomplished by ordinary biennial dredging with spoil deposited on the downcoast beaches to compensate for interruption of the natural littoral supply. However, if the rate of littoral deposition in the channels approaches 300,000 cubic yards annually, a sand bypassing plant would be installed and practically continuous dredging of the channels and placing of material on the downcoast beaches would be accomplished. Using December 1956 price levels, the district engineer estimates the first cost of the improvement, including the sand bypassing plant, at $2,576,000, of which $24,000 is for aids to navigation. The annual carrying charges are $155,000, including $48,200 for operation, maintenance, and major replacements of the sand bypassing plant. He estimates the average annual benefits at $254,540, consisting of $161,800 for recreational boating, $3,600 for sport fishing, $13,200 for land enhancement, $38,240 as the net value of increased fish catch, $30,000 for elimination of fishing-boat damage, and $7,700 for reduction in boat-operating costs. The benefit-cost ratio is 1.64. If the sand bypassing plant is not needed, the benefit-cost ratio would be 1.96. The district engineer concludes that the character and amount of local benefits warrant a cash contribution by local interests toward the first cost of the general navigation features of the project, including the sand bypassing plant, if needed. Accordingly, he estimates that the Federal first cost would be $1,612,000, including $24,000 for aids to navigation, and the non-Federal first cost would be $964,000, including a cash contribution of $858,000, of which $118,000 would be for the sand bypassing plant. The district engineer recommends construction of the improvement in accordance with his plan, subject to certain conditions of local cooperation, with the provision that construction of the sand bypassing plant be deferred until such time as, in the opinion of the Chief of Engineers, the need therefor becomes evident. The division engineer concurs.

6. The president of the Beach Erosion Board concurs with the district engineer that the proposed jetties would cause accretion to the shore to the west and erosion of the shores to the east; and that neither the actual rate of drift nor the impounding capacity of the west jetty can be accurately predicted at this time. He is of the opinion that the annual shoaling rate may well reach several times the minimum amount of 25,000 cubic yards estimated by the district engineer. He concludes that the project, if authorized, should provide for sand bypassing as may be necessary to supply sand to the downdrift shore at the existing normal rate by such method as the Chief of Engineers may determine to be most suitable. He further concludes that prospective beach erosion damages would greatly exceed the bypassing cost and that bypassing is the least expensive method of averting those damages.

7. The Board of Engineers for Rivers and Harbors, having fully considered the reports of the district and division engineers, concurs in the views of the reporting officers and recommends improvement of Santa Cruz Harbor, Calif., to provide for a small-boat harbor in Woods Lagoon, in accordance with the plan of the district engineer, subject to certain conditions of local cooperation.

8. After due consideration of these reports, I concur in the views and recommendations of the Board of Engineers for Rivers and Harbors with the exception of the requirement that local interests control water pollution within the harbor to avoid conditions inimical to health. I recognize the desirability of controlling pollution but do not consider it necessary to include this as a requirement of local cooperation. Accordingly, I recommend improvement of Santa Cruz Harbor, Calif., to provide for a small-boat harbor in Woods Lagoon, consisting of an entrance channel 100 feet wide, 20 feet deep, and approximately 900 feet long, continuing 15 feet deep and the same width for a distance of 370 feet; an inner channel 15 feet deep, 150 feet wide, and 800 feet long, continuing 10 feet deep for an additional 600 feet; a turning basin 10 feet deep, 250 feet wide, and approximately 300 feet long; an east jetty 810 feet long, and a west jetty 1,200 feet long; and a sand bypassing plant; all generally in accordance with a plan of the district engineer and with such modifications thereof as

in the discretion of the Chief of Engineers may be advisable, including deferment of construction of the sand bypassing plant until the need therefor becomes evident; at an estimated cost to the United States of $1,588,000 for construction, including $219,000 for the sand bypassing plant if needed, and $50,000 annually for maintenance, of which $15,000 and $35,000 is for maintenance of the jetties and channels, respectively; provided that, prior to construction, local interests agree to: (*a*) contribute in cash 35.1 percent of the first cost of jetties, channels, and the turning basin, a contribution presently estimated at $740,000 to be paid in a lump sum prior to initiation of construction, the final allocation of cost to be made after the actual costs have been determined; (*b*) contribute in cash 35.1 percent of the first cost of the sand bypassing plant and appurtenances at such time as in the opinion of the Chief of Engineers its need becomes evident, a contribution presently estimated at $118,000; (*c*) provide without cost to the United States all necessary lands, easements, rights-of-way, suitable spoil-disposal areas, and a source of royalty-free jetty stone acceptable to the district engineer, for the construction and maintenance of the project, when and as required; (*d*) hold and save the United States free from damages due to the construction and maintenance of the project; (*e*) acquire and hold in the public interest sufficient lands for construction of the turning basin and public utilization thereof; (*f*) provide without cost to the United States bulkheads, levees, revetments, relocations, and all dredging in the berthing areas, as necessary for the construction and maintenance of the project and necessary berthing facilities and utilities, including a public landing with suitable supply facilities, open to all on equal terms, in accordance with plans to be approved by the Chief of Engineers; (*g*) provide or arrange for suitable marine-repair facilities; (*h*) maintain the entire project except the jetties and dredged depths in the entrance channel, the inner channel, and the turning basin subject to conditions stated in subparagraph (*i*) below; and (*i*) upon commencement of sand bypassing, assume the operation and maintenance of the sand bypassing plant and make replacements thereto, when and as required; and, further, maintain the dredged depths in the entrance channel, the inner harbor channel, and the turning basin, with the understanding that the United States will reimburse local interests for the actual cost of plant operation, maintenance and replacement up to a limit of $35,000 annually; and with the further understanding that the cost of any required channel or basin maintenance incurred by the United States will be deducted from the estimated $35,000 annual Federal reimbursement.

E. C. ITSCHNER,
Major General, USA, Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

Subject: Santa Cruz Harbor, Calif.
From: The Board of Engineers for Rivers and Harbors, Washington, D. C., January 28, 1958.
To: The Chief of Engineers, Department of the Army.

1. Local interests were notified of the recommendations of the district and division engineers and were given an opportunity to present additional information to the Board. All communications received expressed approval of the improvement.

2. The president of the Beach Erosion Board concurs with the district engineer that the proposed jetties would cause accretion to the shore west thereof and erosion of the shores to the east, and concludes that the project, if authorized, should provide for sand bypassing as may be necessary to supply sand to the downdrift shore at the existing normal rate by such method as the Chief of Engineers may determine to be most suitable. He states that evidence developed in the recently completed cooperative beach erosion control study in the area indicates that the value of prospective erosion damage, which would occur to both public and private property, would greatly exceed the bypassing cost and that this is the least expensive method of averting the damage. He further concurs with the district engineer that the actual rate of drift and the impounding capacity of the west jetty cannot be accurately predicted at this time, but he is of the opinion that the annual shoaling rate may well reach several times the 25,000 cubic yards estimated as a minimum by the district engineer.

3. The Board of Engineers for Rivers and Harbors concurs in the views and recommendations of the reporting officers. The Board agrees that insufficient information is available to determine the effects of littoral movement on the harbor channels and the leeward beaches. It is especially important that the plan contain provisions for rectifying any adverse effects it may have on the adjacent beaches, which are so vital to the community and the State and which are at present in need of protective measures. If, after construction of the jetties and normal biennial maintenance dredging, it is found that the rate of littoral movement results in cycles of alternate abundance and starvation of sand for the beaches with corresponding cycles ranging from overdepth to undue shoaling in the channels, then a sand bypassing plant should be installed to provide practically continuous movement of the material. The Board is further of the opinion that the proposed method of maintenance of the harbor and the beaches is equitable and proper and that the United States should participate in the cost of harbor dredging to the extent of contributing an amount not in excess of the cost of the work by the most economical method. The improvement is economically justified.

4. Accordingly, the Board recommends improvement of Santa Cruz Harbor, Calif., to provide for a small-boat harbor in Woods Lagoon, consisting of an entrance channel 100 feet wide, 20 feet deep, and approximately 900 feet long, continuing 15 feet deep and the same width for a distance of 370 feet; an inner channel 15 feet deep, 150 feet wide, and 800 feet long, continuing 10 feet deep for an additional 600 feet; a turning basin 10 feet deep, 250 feet wide, and approximately 300 feet long; an east jetty 810 feet long, and a west jetty 1,200 feet long; and a sand bypassing plant; all generally in accordance with the plan of the district engineer and with such modifications thereof as in the discretion of the Chief of Engineers may be advisable, including deferment of construction of the sand bypassing plant until the need therefor becomes evident; at an estimated cost to the United States of $1,588,000 for construction, including $219,000 for the sand bypassing plant if needed, and $50,000 annually for maintenance, of which $15,000 and $35,000 is for maintenance of the jetties and channels, respectively; provided that, prior to construc-

Additional Attachments
See Appendics A-1 & A-2

A-5

30 January 92 Bill Lee Letter describing 1987
Harbor Entrance Accident

B I L L   L E E   Y A C H T S

January 30 1992

Mr. Tom Kendall
US Army Corps of Engineers
211 Main Street
San Francisco, CA 94102

Dear Tom:

Here is a copy of the Santa Cruz Harbor Survey.

Also I would like to describe an accident at the Harbor Entrance on March 5, 1987. It was during the end of Southerly storm. There was wind out of the South and waves breaking at the entrance. A boat which we had built, the 68 foot sailing vessel, HOTEL CALIFORNIA wished to exit to harbor in route to Southern California. Several of the people on board were locals and were familiar with watching the waves and waiting for a safe time.

They thought the safe time had come and started out, but too soon. Once they saw another wave, they had to decide whether to stop between the jetty's or go for it. The went for it. Somewhere between the end of the west jetty and about 2 boat lengths past, they were motoring at 9 knots straight into a steep breaking wave.

When the boat came down on the backside of the wave, a crewman on the bow had broken his arm. Forward of the keel, the bottom of the boat was extensively damaged and several bulkheads were broken. From the marks on the bottom of the keel, the boat may have hit bottom at some time in the process. Dollar damage to the boat approached $20,000. Crew member could provide medical cost if needed.

The crew member's arm recovered well and boat was repaired, but the area just outside the entrance remains a hazard. The danger of this area may not have been foreseen in the original design of the harbor.

Sincerely,

Bill Lee

FAST IS FUN!

3700 B Hilltop Road   Soquel, CA 95073   (408) 475-9627   Fax: (408) 475-0867

A-6

14 November 91 Harbor Master Letter regarding Proposed Alternatives

SANTA CRUZ
HARBOR

November 14, 1991

Mr. Tom Kendall
Corps of Engineers
211 Main Street
San Francisco, CA 94102

Dear Tom;

Subsequent to our meeting of October 31, 1991, during which we discussed the study alternatives for the Santa Cruz shoaling problem, the Port District's dredging committee met to further refine the Port's priorities among the alternatives. This committee, consisting of Port Commissioners Ed Flavell and Bill Lee, Port Director Brian Foss, and myself, reviewed again the six possible alternatives which you presented.

I would like to comment on your proposed alternatives individually:

#1: No action alternative (i.e. current dredging program).

Obviously, this alternative does not require the effort of a feasibility study, nor the justification of a benefit to cost analysis.

#2: Seal east jetty (i.e. Grout Injection Sealing).

The Port is desirous to see this alternative accomplished; however, it is a small enough project that it probably does not merit the expense entailed in going to the next step of a feasibility study. We hope there would be some method in which the Corps could go directly to funding this as a project. I have enclosed some interesting photographs for your review on this subject. On November 7, 1991, large surf overtopped the beach burm and created a river-effect, which drained through the harbor's east jetty. The turbulence and discolorization of water and sand entering the harbor channel is clearly evident in one of the photos. It is obvious to me that sealing the east jetty would prevent this source of shoaling.

#3: Extension of the existing dredging discharge pipe toward Black's Point to avoid bypassing reversals.

This alternative was discussed at length and it was felt that the Port's position on this for further study is directly related to the order of magnitude. If the extension of the existing dredge discharge pipe is solely limited to our own dredging practice in adding more pipe in a temporary manner further toward Black's Point,

Santa Cruz Port District
135 5th Ave.. Santa Cruz. CA 95062 (408) 475-6161

then little further Corps study is needed. However, if this alternative involves a permanent, engineered pipeline going all the way to Black's Point and perhaps out to sea past the point itself, then we believe that the engineering, environmental and benefit cost analysis of this alternative would need to be studied further through the feasibility stage.

For both these alternatives, the increased costs of extra pipeline and fuel (required to pump farther) will need to be balanced with the potential savings in dredging loss.

#4: Sand trap (Pit Over Existing Pit Shoal).

This alternative could include excavation of a clay layer. It would have to identify a disposal site. I believe this is also an order of magnitude question. If the idea here is to use the Port's existing equipment to dredge as deeply as we can in the harbor entrance; then there would only probably be federal interest involved if the new, deeper channel was deemed to be a "new federal channel." Otherwise, the Port could create a sand trap, at least temporarily, in the entrance using the "Seabright" at our own will.

If this alternative is extended to include excavation of the hardpan clay layer in the entrance area and to the west, then this would be a significant project which would need engineering, environmental and benefit cost analysis through a feasibility study. Generally, the Port's dredging committee was not inclined to recommend any further study of excavation of a clay layer as numerous environmental problems quickly presented themselves.

#5: Fixed jet-pump-type sand bypassing system.

This alternative would be located in the navigation channel and would either use the existing discharge pipeline or parallel it.

It seemed clear to us that this alternative would involve a new federal project, including the acquisition of significant new hardware. The Port would encourage further effort on this alternative, including engineering, environmental and benefit cost analysis.

#6: Mobile jet - pump type system working on west fillet of west jetty.

This system would most likely be crane-operated and bypass sand from west of the west jetty to east of the east jetty.

During the October 31 meeting there was discussion on this alternative to the effect that it might not be a federal project considering that it might not bypass any sand that entered the channel. It was also discussed that it would possibly be

only a method to pass more sand from west of the west jetty to east of the east jetty, benefiting the down-coast neighbors, but perhaps the Port very little. The Port dredging committee considered these ideas further and recommend that alternative #6 be seriously studied. It was our basic feeling that a significant, although undetermined, amount of sand destined for the harbor entrance could be removed before it becomes a problem through this system. We recommend that further engineering, benefit cost analysis be done on alternative #6.

Regarding alternatives #5 and #6, the Port's dredging committee is very interested in encouraging the Corps of Engineers Waterways Experiment Station to use Santa Cruz Harbor as a site for further experiments with mobile jet pumps, particularly in relation to those pumps working in heavy debris environments.

As I'm sure you are aware from our comments at the October 31, meeting, the Port District is very concerned about being able to afford our share of the next step in this process (the feasibility study). Generally, we hope to get as much data as possible from the reconnaissance study, and will be eager to learn about benefit/cost ratios you come up with for the various alternatives.

Hopefully these comments have helped clarify the Port's position and will make the writing of the reconnaissance study a little easier.

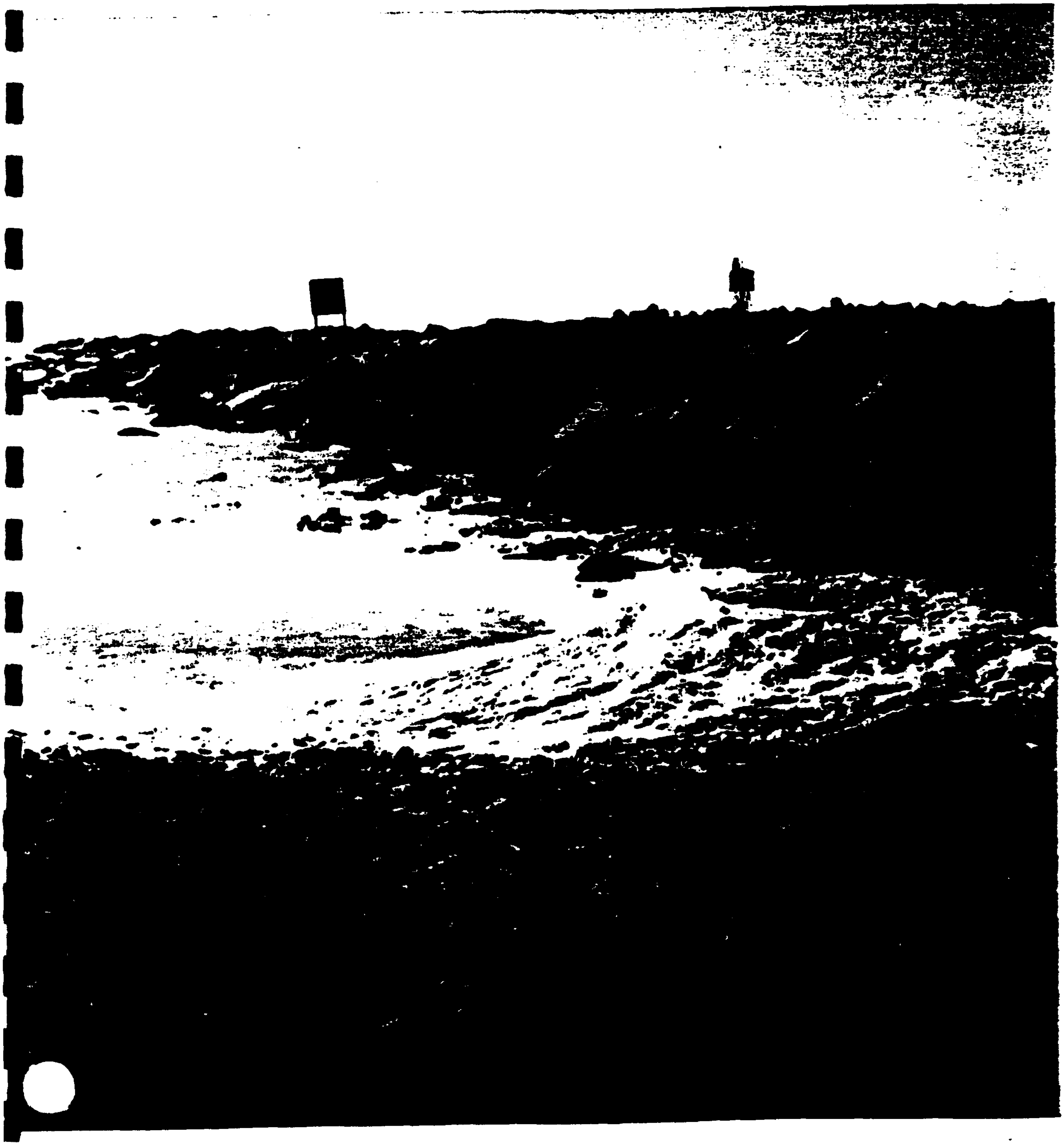
Thanks for your attention to these comments.

Sincerely,

Steve Scheiblauer

Stephen B. Scheiblauer
Harbormaster

SBS:keb
Enclosures: 3 Photos



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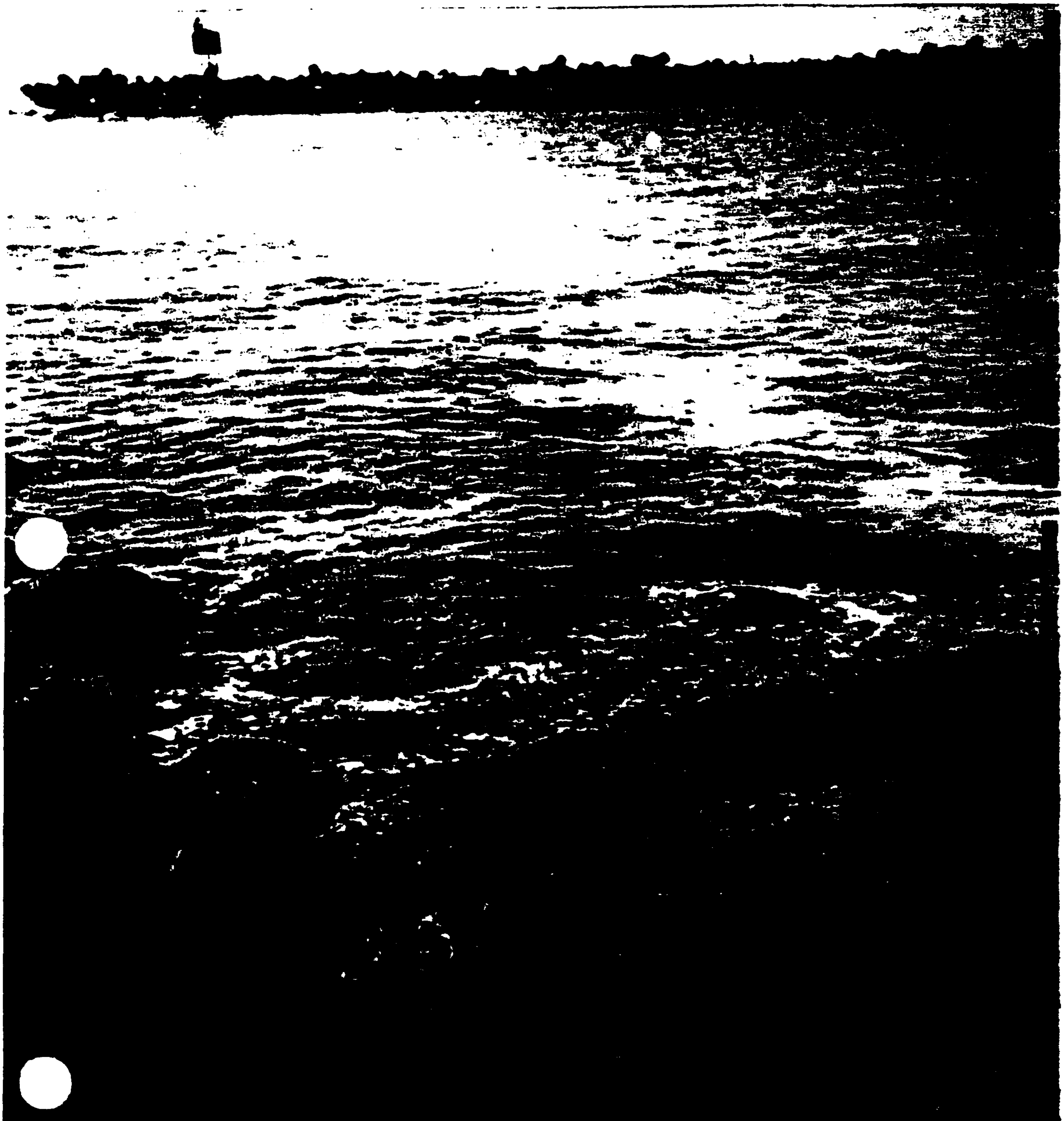

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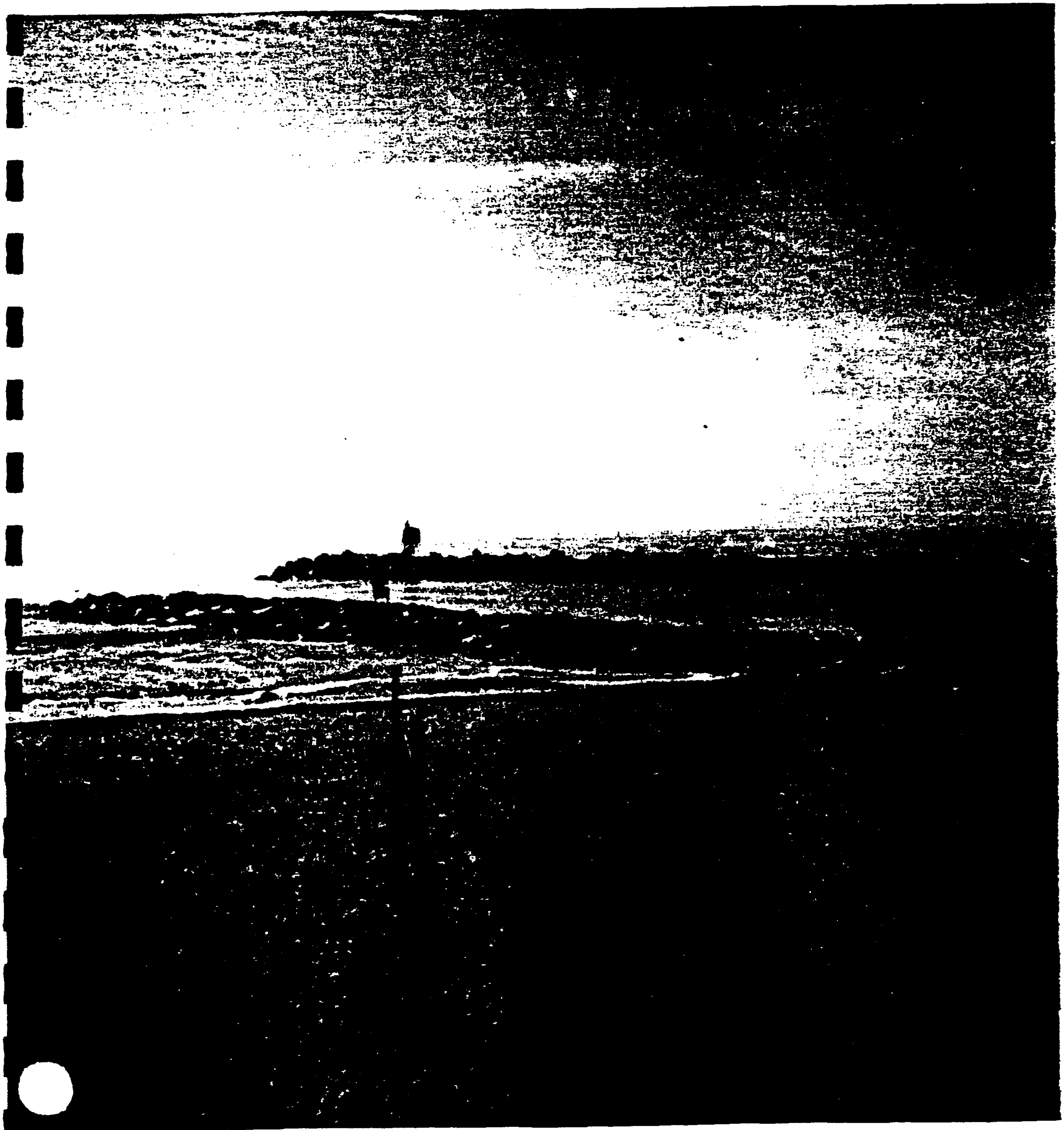

11/7/91

A-7

Congressional Letter Supporting 1992 Authorization
for East Jetty Sealing

LEON E. PANETTA
16TH DISTRICT, CALIFORNIA

CHAIRMAN:
HOUSE BUDGET COMMITTEE

COMMITTEES:
AGRICULTURE
HOUSE ADMINISTRATION
SELECT COMMITTEE ON HUNGER
STEERING AND POLICY

MAJORITY WHIP
FOR THE BUDGET

Congress of the United States
House of Representatives
Washington, DC 20515

WASHINGTON OFFICE:
339 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-2861

DISTRICT OFFICES:
380 ALVARADO STREET
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(408) 637-0500

SALINAS, CA
(408) 424-2229

SAN LUIS OBISPO, CA
(805) 541-0143

SANTA CRUZ, CA
(408) 429-1976

November 6, 1991

Mr. William E. Geisreiter
East Cliff Drive Property Owners
120 13th Avenue
Santa Cruz, California 95062

Dear Mr. Geisreiter:

Thank you for contacting me regarding the Shoreline Protection Study and the Sealing of the East Jetty.

Currently there is no appropriate legislation in which to extend the authorizations of these projects, I therefore intend to assist in obtaining authorization for these projects in next year's Water Resource bill. I have written a letter to Chairman Nowak to request these authorizations and have enclosed a copy for your information.

My staff was informed by staff on the Subcommittee on Water Resources that the deauthorizations will not have a negative effect and that it should not be a problem to get these projects reauthorized.

If I can be of further assistance regarding this matter or any other, please do not hesitate to contact me again.

Sincerely,

LEON E. PANETTA
Member of Congress

LEP/ls
Enclosure

LEON E. PANETTA
16TH DISTRICT, CALIFORNIA

CHAIRMAN
HOUSE BUDGET COMMITTEE

COMMITTEES:
AGRICULTURE
HOUSE ADMINISTRATION
SELECT COMMITTEE ON HUNGER
STEERING AND POLICY

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SANTA CRUZ, CA
(408) 429-1976

November 6, 1991

The Honorable Henry J. Nowak
Chairman, Subcommitee on
Water Resources
B-376 Rayburn House Off. Bldg.
Washington, D.C. 20515

Dear Mr. Chairman:

I am writing to ask your assistance in gaining authorization for two water projects that are due to expire on November 17, 1991: 1. The Santa Cruz County Shoreline Protection and 2. The Santa Cruz Harbor Sealing of East Jetty.

The Santa Cruz Harbor Sealing of the East Jetty was originally authorized in 1986 under public law 99-662. The Santa Cruz County Erosion Control Study was originally authorized in 1958 under House Document No. 179, 85th Congress, 1st Session May 20, 1957. Unfortunately, these studies have never received federal funding and thus, are subject to automatic deauthorization. The East Jetty project has not started because there is still a reconnaissance study underway that will determine what modifications of the jetty are necessary. The Erosion Study is needed because this shoreline is threatened.

It is for these reasons that I am requesting that you include these projects in the Water Resources bill next year. I certainly appreciate the support you have given to the various projects in my district in the past and hope that you will be able to include this request in the 1992 bill.

Thank you for your assistance with this matter.

Sincerely,

LEON E. PANETTA
Member of Congress

LEP/ls

Appendix B

Sediment Budget and Surge Study

SANTA CRUZ SHOALING STUDY

HARBOR ENTRANCE SEDIMENT BUDGET

Prepared For:

AQUA RESOURCES, INC.
2030 Addison Street, Suite 500
Berkeley, California 94708

Under Contract DACW07-89-D-0031 with:

U.S. ARMY CORPS OF ENGINEERS,
SAN FRANCISCO DISTRICT
211 Main Street
San Francisco, California 94105-1905

Prepared By:

MOFFATT & NICHOL, ENGINEERS
131 Steuart Street, Suite 300
San Francisco, California 94105

Assisted by:

GARY B. GRIGGS & ASSOCIATES
306 Dickens Way
Santa Cruz, California 95064

Robert T. Battalio
Registered Civil Engineer

M&N Job No. 2998

FINAL

MARCH 27, 1992

CONTENTS

I. INTRODUCTION

A. BACKGROUND

Santa Cruz Harbor is located on the northern coast of Monterey Bay, about 65 miles south of San Francisco. Figure I-1 shows the location of Santa Cruz Harbor and Figure I-2 shows the harbor and shoreline configuration.

Santa Cruz Harbor entrance was designed by the U.S. Army Corps of Engineers (Corps). Construction was jointly sponsored by the Corps and the Santa Cruz Port District (SCPD). Construction of the entrance jetties began in 1962 and was completed in 1963.

Within several years of construction, substantial amounts of sand accumulated to the west of the jetties and within the entrance channel. Maintenance dredging was implemented to maintain a navigable entrance, with sand discharged to the east to supply downdrift shores. Several studies have been conducted to better understand the sediment transport and shoaling processes in order to better manage the entrance channel. One such study was conducted by Moffatt & Nichol, Engineers (1978) for the Corps. The SCPD, with assistance from the Corps, purchased a dredge specifically designed for Santa Cruz in 1986. The SCPD has operated this dredge when needed since that time, and has maintained a navigable entrance since 1986.

The Corps is conducting a reconnaissance study of the potential feasibility and benefit of possible modifications to the Santa Cruz Harbor entrance and dredging practices. Sediment transport processes in the vicinity of the harbor entrance are pertinent to the reconnaissance study. Since the 1978 study, annual dredge volumes have increased (Figure IV-3 shows the dredging history). It was not clear if this change was related to the new dredging practices only, or if the amount of sediment moving toward the entrance had increased. This issue required an assessment of long-term (multi-year) trends in sediment transport processes. Assessment of short-term sediment transport processes (seasonal and storm) were desired for several reasons. First, the potential for westward transport of sand from the beach discharge area to the dredge area affects the utility of alternative discharge practices. Second, the maximum quantity of sand that could shoal the entrance during one or a series of storms affects the design criteria for dredging practices. In a general sense, an understanding of sediment transport processes was required to gage the potential impacts and benefits associated with modifications to the entrance structures and dredging practices. In addition, the Corps and the SCPD desire to avoid any modifications that could worsen the existing problems associated with surge (long ocean waves) in the harbor.

B. PURPOSE

The purpose of this reconnaissance-level study is to update the Santa Cruz Harbor Entrance Sediment Budget from the 1978 report, assess the probable effect of harbor modifications on harbor response to surge and identify actions that could reduce problems associated with surge.

C. SCOPE OF WORK

All work is of reconnaissance-level only. The scope of work is described as follows:

1. <u>Collect, Compile and Analyze Beach Profile Data</u>

Compare historic and recent beach profiles surveyed near the entrance. Collect monthly beach profiles. Address long-term and short-term (seasonal and storm-related) changes.

2. <u>Update Sediment Budget</u>

Use beach profile data, shoreline positions (from aerial photographs), potential longshore sand transport rates (calculated using wave gage data), and reports to update the harbor entrance sediment budget presented in the 1978 Moffatt & Nichol, Engineers report. This analysis involves a volumetric accounting of sediment sources and sinks, and sediment transport processes and rates. Address long-term and short-term (seasonal and storm-related) changes. Also investigate whether the updrift beach continues to accrete, and whether accretion extends updrift past the San Lorenzo River. Select and investigate a "control" beach outside the study area for reference.

3. <u>Investigate Harbor Response to Surge</u>

Investigate surge (long-period wave) activity in Santa Cruz Harbor by discussions with SCPD personnel, review of prior studies, and application of an approximate numerical model. Address the potential for proposed entrance modifications to affect harbor response to surge. Identify actions that could reduce surge or damages associated with surge.

II. BEACH PROFILE AND SURVEY DATA

A. PREVIOUS WORK

1. Army Corps of Engineers

The Army Corps of Engineers began surveying Seabright and Twin Lakes beaches in 1953. Two profiles lines were originally established: one at the upcoast end of Seabright Beach, just east of San Lorenzo Point (Monument 13), and one approximately at the middle of Twin Lakes (Monument 15) (Figure II-1). In 1958, profile line 6+00E was added. In 1961, additional profile lines were added to include the entire stretch of shoreline from San Lorenzo Point to Blacks Point. From 1961 to 1966 beach and nearshore surveys were conducted one to three times a year for most of these lines. No data were collected from August 1966 to February 1975. From February 1975, to February 1978, beach surveys were collected one or two times a year. In addition, thirty one hydrographic surveys of the harbor's channel and the area around the jetties were carried out from January 1975 to May 1979.

2. Gary B. Griggs & Associates

From February 5, 1991 to June 26, 1991, a bi-weekly survey program at Twin Lakes Beach was carried out for the Santa Cruz Port District. Thirteen shore normal profile lines, spaced at 100 foot intervals, were surveyed from the back beach out to approximately the -10 foot Mean Lower Low Water (MLLW) contour. These data were collected with the objective of attempting to track transport direction of the sediments discharged during harbor dredging.

B. METHODOLOGY AND DATA COLLECTION FOR PRESENT SURVEY

1. Surveying Efforts

Two Surveying efforts were accomplished as part of this study. First, ten beach profiles located east and west of Santa Cruz Harbor were surveyed about once a month from September to January. Secondly, the sand shoal adjacent to the west jetty and harbor entrance was surveyed along lines oriented radially from the west jetty three times during the study period. Figure II-1 shows the locations surveyed.

The present beach and offshore survey was initiated in late August, 1991 and continued on a monthly basis through January of 1992 (Table II-1). The survey area extended from San Lorenzo Point to Blacks Point, an alongshore distance of approximately 5000 feet, and included Seabright, Twin Lakes and 12th Avenue beaches.

Ten profile lines were established (Figure II-1) to coincide as closely as possible with the previous historic survey lines. These survey lines extended from the backbeach at the base of the seacliff, across the shoreline to offshore depths of approximately -30 feet MLLW.

A Leitz Set-2 Electronic Distance Meter (EDM) was used for both on- and offshore portions of the survey. Shore parallel baselines were initially established on all three beaches, and temporary bench marks (TBM) were set along the baseline. For the beach and offshore profile surveys, the EDM was positioned on the beach near the berm. The TBMs were surveyed to determine the position of the EDM using triangulation. This was accomplished by knowing the distance between the TBMs, the distances to the TBMs, and the angle between the TBMs from the field station.

The beach and nearshore portions (to wading depths) of each profile line were surveyed using a field assistant in a wet suit holding a 12 foot pole with a prism reflector. The offshore portions of each profile line were collected with a continuous recording fathometer mounted on a 17 foot Boston Whaler. The position of the boat was surveyed from the shore-based EDM in order to fix points along the profile.

The west jetty shoal survey was conducted with a digital fathometer (accurate to one foot) on board one of the small boats operated by the Santa Cruz Port District. A series of radial lines extending out from the dogleg portion of the west jetty were reoccupied from September to December (Figure II-1). During these surveys the EDM was set up on the tip of the west jetty, directly over C.O.E. BM 21+00, and the position of the boat was surveyed approximately 10-15 times per line. The date of each survey and the area covered are listed in Table II-2.

2. Santa Cruz Harbor Dredging During the Survey Period

The SCPD began it's annual dredging operations on November 15, 1991. From November 15 to January 16, 1992, the entrance channel was dredged (Table II-3). From January 20-24, the turning basin was dredged. Personal communication with the SCPD indicate that approximately 110,000 cubic yards of predominantly sand sized material was dredged from the entrance channel and released on Twin Lakes Beach during the study period.

3. Environmental Conditions During the Surveying Period

Throughout most of the study the surveys were conducted when the surf was one to two feet. The swell was twice one to three feet, and on the day of the last survey the swell was two to three feet (Table II-4). Northwest swells were predominant during the course of the study, and on all beaches in the study area the swells broke within 10 degrees of shore perpendicular (Table II-4). Winds were variable, ranging from 0 to 20 miles per hour, while the visibility was good throughout the course of the study.

4. Data Manipulation

Data from the monthly beach surveys are plotted as topographic/ bathymetric profiles. These profiles are shown on Figures II-2 to II-11. Figure II-12 shows a comparison of these data and data collected by Hicks (1982) at profile line 2 only.

Selected profiles from the west jetty shoal area were computer plotted to facilitate comparisons during the four months of this study, as well as for comparisons with previous hydrographic surveys in this same area (Figures II-13 to 17). Data from Corps of Engineers hydrographic maps from October 1975, and May 1979, were used to plot comparable profiles. These two surveys extended far enough offshore to provide useful comparisons with the data from the 1991 surveys. Individual overlay plots with profile data from the 1975 and 1979 maps and all 1991 surveys were computer plotted for the 0, 20, 40, 320 and 340 degree profile lines. These specific radial lines were chosen using two criteria: 1] they cover most of the area of interest without going into the dredged channel, and 2] the 1991 surveys went especially smooth along those lines, and the data are therefore the most accurate. In addition, the data from the shoal survey were used to create computer drafted topographic/ bathymetric contour maps and 3-D block diagrams (Figures II-18 to 25). Calculated volume differences between successive shoal surveys are listed in Table II-4.

C. *RESULTS*

1. Long Term Changes

a. Beach Profiles: As one approach to evaluating any long term accretion or erosion along the shoreline from San Lorenzo Point to Blacks Point, the shore normal distance of the summer berm crest and the MLLW contour from the base line was measured on each plotted profile. These historic and recent data were then plotted against the date of each survey to graphically portray these trends over time (Figures II-26 to 29).

Lines 2, 3 and 4 cross the west, middle and east ends of Seabright Beach, respectively (Figures II-1,26,27,28). These graphs clearly show the extent of post-harbor accretion of Seabright Beach (1963-1965), and also reveal that the Seabright Beach fillet was essentially full or had reached equilibrium by about 1977. Both the position of the berm crest, and the location of the MLLW contour show identical patterns, with no significant accretion between the last historic survey in 1977 and the resurveys of late summer 1991 to early winter 1992. The overlay of the 1991 survey profiles 2-4 and the survey lines from the 1970's, along with Figure II-12 further demonstrate the attainment of equilibrium on Seabright Beach by the mid 1970's. Seabright beach survey data collected by Hicks in 1982 at the approximate location of survey line 2 was recovered and plotted

in Figure II-26 for additional control on the timing of the attainment of equilibrium.

Line 4, adjacent to the west jetty, is the only profile that appears to show any growth since the last historic survey (Figure II-28). The last survey of line 4, however, was in winter 1975, not summer. There has been an increase in the beach volume as computed from the profile comparison. The volume (two dimensional cross-sectional volume increase of approximately 2250 square feet between 2/75 and 10/91), however, is less than the volume difference measured between 9/28/91 and 12/01/91 (2470 square feet). The fact that the accretion or profile change between February 1975 and October 1991, is less than the bi-monthly fluctuation during the study period indicates the adjacent accretion is likely due to short-term fluctuations rather than long-term trends. A comparison of Hicks' (1982) profiles with those surveyed during this study along line 2 indicate that the western end of Seabright beach has not changed significantly since 1982 (Figure II-12).

Similar historic plots of the beach width of Twin Lakes and 12th Avenue beaches show no significant change since the late 1970's. A graph of the summer berm and MLLW position by year was developed for profile line 10 to document any long term accretion or erosion on the beaches immediately downcoast of the harbor (Figure II-29).

Erosion downcoast of the harbor immediately following it's construction, and the subsequent slow recovery is well documented for profile 10 in Figure II-29. It is not as clear from these data that Twin Lakes and 12th Avenue beaches have reached equilibrium, largely due to the 14 year gap in the record between 1977 and 1991. The profiles show that there has been no growth to either Twin Lakes or 12th Avenue beaches since the late 1970's. Both beaches are currently at almost the exact same position throughout the entire profile as they were in the late 1970's.

A consistent closure depth of approximately -20 feet MLLW was found on all beach profiles throughout the study area and through the historic and recent surveys except for the January, 1992 profiles, which did not close. The offshore portions of all profiles do not show any consistent change below the -20' MLLW contour from 1953 to present. Offshore changes appear to be attributable to seasonal or yearly fluctuations rather than any net long term changes.

b. West Jetty Shoal: Results of the radial shoal survey around the west jetty and comparisons with the October 1975, and May 1979, hydrographic surveys are shown in Figures II-13 to 17. In comparing these profiles it is important to keep in mind that the digital fathometer provides depth readings to the nearest foot,

and that the wave interference can be significant when the boat is close to the jetty.

Overall, the jetty shoal profiles recorded between November and December are quite similar down to depths of about -15' MLLW. At greater depths, the differences between those two surveys are as large as the differences between the late 1970's and 1991 surveys, suggesting that the overall net change in this 12 to 16 year time span has been relatively small, with the greatest apparent accretion having taken place closest to Seabright Beach.

Table II-4 provides a summary of calculated volume differences. The change of 16,182 cubic yards from May 1979 to September 1991 is less than the 21,796 cubic yards from September to December 1991. This suggests that there has been no clear long term pattern of either accretion or erosion in the shoal area since May 1979. The differences between the historic and recent profiles most probably reflect typical seasonal variations, or perhaps yearly fluctuations, rather than significant net accretion.

2. Short Term Changes

a. Profiles: From 9/28/91 to 12/01/91, all three beaches in the study area appear to exhibit a closure depth of approximately -20' MLLW. From 12/01/91 to 1/23/92 closure was not reached on most of the profiles. Little significant difference is apparent in the profiles from 9/28/91 and 10/28/91. There were no storms of significant intensity during this time period. The storms which occurred in November and December, however, did bring about some changes in the profiles. Seabright Beach remained very stable at mid-beach, lines 2 and 3, but at the upcoast and downcoast ends of the beach there were significant changes (Figures II-2,3,4). The upcoast end of the beach was eroded, the mid-section remained essentially unchanged, and the downcoast end accreted during the November storms. During the December storms the upcoast end of the beach eroded below the -15' MLLW, the mid-section eroded slightly, and the downcoast end eroded throughout it's profile.

Overall, two trends are apparent: A clockwise rotation of the shoreline and nearshore, and overall erosion. both of these short-term trends are attributed to the change in wave conditions during the study period. The beach segment between the harbor jetties and Black Point changed in a similar manner, except greater erosion occurred.

The most dramatic changes in the study area occurred on Twin Lakes beach (Figures II-6 to 9). All the profiles experienced erosion on a monthly basis, the most significant occurring on line 6. From 9/28/91 to 12/01/91, line 6 lost a two dimensional volume of approximately 2750 square feet. During this same

period, lines 5 and 7 lost about half that volume, while line 8 remained fairly stable, except for the berm position, which retreated 132 feet. No significant changes occurred below -20 feet MLLW, and most changes occurred above -7 feet. Significant sand bar formation was not observed.

b. West Jetty Shoal: Between September and December, 1991 surveys, about 22,000 cubic yards of sand accumulated in the shoal area. Of this volume, about 14,000 cubic yards accumulated in November (See Table II-4). This accumulation may be related to the rotation of the beach in plan view identified previously. The implications to sand bypassing of the west jetty or entrance shoaling are not clear, however there is evidently some storage capacity in the shoal area.

c. Effects of Dredge Dishcarge: Sand dredged from the harbor entrance and discharged to Twin Lakes Beach totaled about 110,000 cubic yards during the survey period. There is no evidence that this material added any significant accretion to either Twin Lakes or 12th Avenue beaches. During the period of study, which coincided with initial dredge operations, Seabright, Twin Lakes and 12th Avenue beaches all were undergoing winter scour. The 1991 "Investigation of the Dispersal of Dredge Spoils from the Santa Cruz Harbor" by Griggs & Associates states that even during mild wave conditions, the discharged sediment is rapidly dispersed and no pattern of deposition is apparent, aside from a short term bulge at the dishcarge point. The dredge operations did not have any discernable impact on the profile of any beaches in the study area during the course of the investigation.

Table II-1:
Dates and Area of 1991-1992 Surveys

Date	Area Surveyed
09/27/91	Shoal off the dog leg of the west jetty
09/28/91	Offshore portions of Beach Profiles 1-10
09/29/91	Onshore portions of Beach Profiles 1-8
09/30/91	Onshore portions of Beach Profiles 9 & 10
10/27/91	Offshore portions of Beach Profiles 1-10
10/28/91	Onshore portions of Beach Profiles 1-10
11/01/91	Shoal off the dog leg of the west jetty
12/01/91	Offshore portions of Beach Profiles 1-10
12/02/91	Onshore portions of Beach Profiles 1-10
12/12/91	Shoal off the dog leg of the west jetty
01/16/92	Offshore portions of Beach Profiles 1-10
01/23/92	Onshore portions of Beach Profiles 1-10

Table II-2:

Environmental Conditions During Period of Study

Date	Surf Conditions						
	Wave Height	Period	Direction*	Tidal Range	Temp.(°F)	Atm Press.(in. Hg)	Wind(mph)
9/28/91	1'-3'	13 sec	270	+4.38 => +4.85	66	30.25	-
9/29/91	1'-2'	13 sec	280	-	-	-	-
9/30/91	1'-2'	13 sec	270	-	-	-	-
10/27/91	1'-2'	-	280	+5.29 => +1.40	-	-	NW ~5-10
10/28/91	1'	-	-	-	-	-	NE
11/01/91	-	-	-	+1.78 => +3.60	-	-	-
12/01/91	1'-2'	13 sec	270	+2.88 => +0.41	64	30.75	NE ~20
12/02/91	1'	-	275	-	-	-	-
12/12/91	-	-	-	+3.80 => 3.00	-	-	-
1/16/92	1'-3'	14 sec	-	+3.03 => -1.04	65	31.00	NE ~0-4
1/23/92	2'-3'	12 sec	280	-	59	30.80	SE ~0-5

* Shore normal = 270

Table II-3:
1991-1992 Dredging Schedule

Date	Area Dredged *
Nov. 15 - Dec. 23, 1991	Entrance
January 2 & 3, 1992	Entrance
January 6 - 9, 1992	Entrance
January 13 - 16, 1992	Entrance
January 20-24, 1992	Turning Basin
January 27-30, 1992	Upper Harbor
February 3-6, 1992	Upper Harbor
February 10-13, 1992	Upper Harbor
February 17-20, 1992	Upper Harbor
February 24-27, 1992	Entrance
March 2-5, 1992	Entrance
March 9-12, 1992	Entrance
March 16-19, 1992	Aldo's / Fuel Pier
March 23 - April 9	Entrance / Channel

* Discharge location for the dredge spoils was between survey lines 6 & 8 throughout the study period

Table II-4:
Volume Changes Between Shoal Surveys

Period	Volume Difference
05/18/79 - 09/27/91	16,182 cubic yards
05/18/79 - 11/01/91	23,748 cubic yards
05/18/79 - 12/12/91	37,978 cubic yards
Average long term	25,969 cubic yards
09/27/91 - 11/01/91	7,566 cubic yards
11/01/91 - 12/12/91	14,230 cubic yards
09/27/91 - 12/12/91	21,796 cubic yards
Average short-term	14,528 cubic yards

III. HISTORIC SHORELINE POSITIONS

A. PREVIOUS WORK

Prior work regarding shoreline positions in the vicinity of Santa Cruz Harbor is presented in the 1978 Moffatt and Nichol report, "Santa Cruz Harbor Shoaling Study" (Figure III-1).

B. METHODOLOGY AND DATA USED

Shoreline mapping was accomplished using available historic aerial photos. Data was analyzed for long and short term trends. The area studied in Santa Cruz extends from Cowell's Beach to Black Point Figures I-1 and III-2). Shoreline positions for New Brighton Beach were also investigated (Figures I-1 and III-3). New Brighton Beach was selected as the best "control" beach available as a measure of regional shoreline changes not affected by the harbor. Additional shoreline maps are found in Section VIII Technical Appendices Figure A-1 and A7.

Historic shoreline positions from the 1940's to the present were delineated using the aerial photographs listed in Table III-1. The 1943 and 1956 photographs were selected to represent conditions prior to the construction of Santa Cruz Harbor. The remaining photographs were selected to augment previous work, and are therefore post-1974.

The wetted bound, which is the line forming the boundary between sand saturated at the time of high tide and drier sand landward of that limit, was chosen as the best shoreline position marker. The wetted bound does not vary appreciably over a tidal cycle; it is identifiable on most coastal aerial photographs; it is continuous along the shore; and it approximates the Mean High Water (MHW) to Mean Higher High Water (MHHW) datums used on survey maps. The wetted bound position is dependent upon changing wave conditions, tidal elevation, and water table fluctuations which cause variations from an "average" location.

A photogrammetric device called a "zoom-transfer-scope" was used to compensate for photographic distortions such as tilt, scale, and perspective. Planimetric maps prepared by the City of Santa Cruz and the Soquel Creek Water District were used to estimate true distances between objects on the aerial photos and to locate the baseline. This procedure has been derived to minimize distortions inherent in aerial photographs, but is still subject to some inaccuracies which are partially dependent on the quality of the photographs used. Photographs were selected to minimize these inaccuracies.

After plotting shoreline positions in Santa Cruz, it was apparent the shorelines were aligned in three sectors. These were identified as Cowell's Beach to the San Lorenzo River, the San Lorenzo River to the Harbor entrance, and the Harbor entrance to Black Point. For analysis these were identified as sectors one, two and three, respectively. A baseline was established for analysis of shoreline locations. This

line remains roughly parallel with the shoreline in each sector (Figure III-2).

For each sector, the shoreline positions were referenced as the average distance between the shoreline and baseline. This allows graphical representation of trends in seasonal shorelines (Fig. III-4). Average seasonal shoreline positions were established by taking a station by station average of positions for October and Winter/Spring (January to May) of all post harbor shorelines (Figures III-5,6,7). In addition, the average seasonal change in position at each station was compared to a measured change (Figure III-8) and the range of positions and net change from 1974 to 1989 were calculated (Figure III-9). Additional plots of shoreline positions are shown in Appendix B. Pre- and post-Harbor shorelines are compared in Figure III-10.

C. RESULTS

1. Long-Term Changes in Shoreline Positions

There have been no discernable long-term trends in shoreline position change since the 1970's at either the Santa Cruz or the New Brighton study areas. This means that the shorelines fluctuate within a stationery range, or that long-term movements are small and therefore "masked" by relatively larger short-term changes.

The pre-harbor shoreline between Cowell's Beach and Black Point was a hook-shaped bay. A natural rock outcrop just east of the San Lorenzo River mouth divided the bay into two sectors. This outcrop acted as a downcoast control for the western sector, impounding sand and forming a wider beach to the west. Similarly, Black Point acted as a downcoast control for the eastern sector.

The post harbor shoreline between Cowell's Beach and Black Point has remained a hook-shaped bay but has been substantially affected by the Santa Cruz harbor entrance jetties. The jetties act as a downcoast control for shoreline positions as far west as the rock outcrop near the San Lorenzo River. Accretion due to the jetties does not appear to extend west beyond the rock outcrop. The jetties also act as an upcoast control for the beach to the east, resulting in a minor hook-shaped alignment for the shoreline as well as a small amount of accretion within several hundred feet.

2. Short-Term Changes in Shoreline Positions

Seasonal fluctuations are characterized by the beaches being widest in the Summer and Fall and narrowest in the Winter and Spring. On average, the seasonal change is about 25 feet to 100 feet west of the Santa Cruz harbor and 50 feet to 200 feet to the east. The greatest changes occur within 2000 feet to the east of

the east jetty.

The maximum range of shoreline positions between 1974 and 1989 was consistently between 150 feet and 200 feet to the west of the harbor but 150 feet to 325 feet between the harbor and Black Point.

These data indicate the harbor entrance jetties and dredging practices may contribute to greater shoreline variability to the east of the harbor.

TABLE III-1
AERIAL PHOTOGRAPHS UTILIZED TO IDENTIFY
HISTORIC SHORELINE POSITIONS

Date	Coverage: Cowells-Black Pt.	Coverage: New Brighton
Summer/Fall		
10/43	X	0
10/74	X	0
10/76	X	X
10/77	X	X
10/82	X	0
10/89	X	X
Transition		
6/56	X	0
6/80	X	X
6/89	X	X
Winter/Spring		
7/78	X	X
1/82	X	X
4/84	X	X
3/86	X	X

Key

X used
0 not used

IV. SEDIMENT BUDGET ANALYSIS

A. PREVIOUS WORK

Many studies have been conducted for the Santa Cruz Harbor and surrounding areas. These include the 1978 Moffatt and Nichol, "Santa Cruz Harbor Shoaling Study" (Figure IV-1), as well as individual reports such as Griggs & Best, "A Sediment Budget for the Santa Cruz Littoral Cell", 1991.

B. METHODOLOGY AND DATA USED

1. Long-Term Changes in Sediment Budget

Analysis included review and tabulation of data from previous reports (Tables IV-1,2,3). In addition, potential longshore sand transport rates (gross and net) were provided by the Corps. These estimates were developed by Scripps Institute from wave data obtained by the Corps of Engineers (Santa Cruz S_{xy}, 1978-1982). The S_{xy} wave gage was located just offshore of the west jetty. There is some uncertainty regarding the exact orientation of the gage. The analysis was derived from the set of information corresponding to the 16 degrees beach normal. It is important to note that Scripps has changed their procedure for analyzing S_{xy} have gage data, resulting in larger estimates of potential longshore sediment transport then reported previously (personal communication with Tom Kendall, Corps of Engineers). Other key sources were Santa Cruz Port District dredging reports (up to 1990), and Griggs, "Sediment Budget for Santa Cruz" (1991), and others.

A series of sediment budget equations were developed. The ranges of values established from previous work were used to conduct a sensitivity analysis of the key terms. The result of the sensitivity analysis allows a narrowing of the range of values and a better estimate of each budget term.

This analysis assumes the shorelines are in equilibrium based on the result of the historical shoreline analysis (no long-term trends).

Assuming all material entering the channel must be dredged, the following system of equations was developed:

(All terms Q are in cubic yards per year)

$$Q_N = Q_L - Q_R$$
$$Q_R = (0.10 \text{ to } 0.40)Q_L$$

$$d_R Q_R = (0.10 \text{ to } 0.15)d_L Q_L$$

$$Q_D = d_R Q_R + d_L Q_L + d_A Q_A + d_{IN}\, Q_{IN} + Q_{LK} + Q_{ON} - Q_{OFF}$$

where:

Q_N = Net Longshore Transport Rate

Q_R = Upcoast Transport Rate

Q_L = Downcoast Transport Rate

Q_D = Quantity to be Dredged

Q_A = Aeolian Transport Rate

Q_{LK} = Leakage Through Jetty Voids

Q_{ON} = Onshore Transport Rate

Q_{OFF} = Offshore Transport Rate

Q_{IN} = Seasonal Influx Rate

d_R = Proportion of Q_R into Channel

d_L = Proportion of Q_L into Channel

d_A = Proportion of Q_A into Channel

d_{IN} = Proportion of Q_{IN} into Channel

The factors of (0.10 to 0.40) for Q_R/Q_L and (0.10 to 0.15) for $d_R Q_R/d_L Q_L$ were established from analysis of wave gage data and previous reports.

The updated ranges of all parameters but d_R, d_L, Q_R and Q_L were used in the sensitivity analysis and values for these four quantities were calculated.

2. Short-Term Changes in Sediment Budget

Short term changes were analyzed by calculating volume changes in the entrance due to large swell conditions. This required analysis of Santa Cruz Port District survey data from this year's storm period of Nov. 10-24, 1991. This data gives insight to typical, single-storm events contributing to shoaling of the entrance. Theoretical estimates of single event volumes were based on the 1978 Moffatt and Nichol study and S_{xy} wave gage data provided by the Corps. Also, survey data and dredge quantities were reviewed.

C. RESULTS

1. Long-Term Changes in Sediment Budget

The following values are estimated for each of the sediment budget terms (Figure IV-2). Units are cubic yards per year.

TERM	RANGE	ESTIMATE
Q_N net longshore	300,000 - 500,000	same
Q_A from west	3,000 - 5,000	5,000
from east	1,000 - 2,000	2,000
Q_{IN} from west	5,000 - 10,000	7,000
from east	2,000 - 5,000	3,000
Q_D dredged	145,000 - 250,000	200,000
Q_{LK} from west	5,000 - 10,000	8,000
from east	2,000 - 6,000	5,000
d_LQ_L transport around west jetty	115,000 - 175,000	150,000
d_RQ_R transport around east jetty	10,000 - 40,000	20,000

The increases in dredge volume and transport around the west jetty into the channel are believed to result from the change in dredging practices (Table IV-4 and Figure IV-3). Instead of episodic dredging, as was done earlier, the harbor district currently conducts nearly continuous dredging during the Winter/Spring season. This allows maintenance of a navigable channel a higher percentage of the time. It should be noted that pre-1986 dredge quantities are pay volumes based on comparisons of pre- and post-dredge bathymetric surveys. The actual amount dredged is probably higher than the pay volume.

The rate of sand movement through the west jetty was estimated with consideration given to the jetty sealing operations performed in the mid 1980's. After discussion with the harbor district as well as study of photographs of the east jetty, the leakage through the east jetty was increased slightly. This term also includes sand movements over and through the shore-side of the east jetty, as observed by the SCPD this year.

2. Short-Term Changes in Sediment Budget

Sand transport associated with a single storm can shoal the entrance to the level where boats cannot safely navigate. The following values are provided as an estimate of short-term shoaling rates.

a. Potential Longshore Transport: Several methods are available to calculate the potential longshore sand transport rate based on wave or current data. These methods rely on wave energy and momentum considerations which, depending on sediment supply and other factors, can indicate potential rates that exceed actual rates. Due to the complexity of the physical processes involved, these methods are considered accurate within 50 percent (plus or minus), not including the accuracy of the wave or current data used for input. Also, these potential longshore transport rates would likely exceed channel shoaling rates due to natural bypassing of the entrance.

Two sets of potential longshore transport rates are available, as summarized below. Moffatt & Nichol, Engineers (1978) used hindcast wave statistics that were numerically transferred from deep water to breaking depths by considering refraction and shoaling. Additional calculations were conducted assuming breaking wave conditions possible during an extreme event at Santa Cruz. More recently, the Corps provided the results of longshore transport calculations using shallow water wave data from a S_{xy} wave gage located near the entrance. While recorded data is often considered superior to hindcast statistics, wave measurement in the surf zone is subject to interpretations implicit to the data collection and analysis programming. The record includes gaps where the gage did not function. Also analysis methods have been modified in the last few years, resulting in substantially different calculations. Finally, calculations are very sensitive to gage orientation, which is not precisely known.

Source/Term	Estimate
Moffat & Nichol Engineers (1978) Maximum Potential Eastward	24,000 to 48,000 in 1 day
S_{xy} Gage Data Maximum Potential Eastward	85,000 in 4 days
Maximum Potential Westward	8,000 in 2 days

b. Actual Shoaling Rates: Shoaling rates were estimated based on a comparison of hydrographic survey data, and dredging records. These data are therefore indicative of the rates of entrance shoaling, and do not include the rates at which sand may bypass the entrance. The maximum shoaling rate reported appears to be limited by the available storage volume of the dredged entrance: Once the entrance is shoaled, most sand will simply bypass the entrance. This indicates that increasing the size of the dredged entrance could result in higher shoaling rates. The calculated potential rates (previous section) exceed the measured shoaling rates. Estimates are summarized below in cubic yards:

Source/Term	Estimate
Moffatt & Nichol (1978) Average of extreme monthly rates, 1970's	30,000 in 1 month
SCPD Dredging Records November, 1988 extreme event	11,000 in 1 day
Comparison of SCPD Soundings November 1991, moderate event	15,000 in 4 days
SCPD Dredging Records November 1991 to January 1992	110,000 in 2.5 months

TABLE IV-1

LONGSHORE TRANSPORT (NET)

ESTIMATES FROM PRIOR STUDIES
(METHODOLOGY VARRIES)

ESTIMATE (CY/YR)	SOURCE
270,000 (MAXIMUM)	ANDERSON, 1971
191,000	MOORE, 1972
300,000 - 500,000	M&N, 1978
61,500	SEYMOUR, ET AL, 1980
149,100 - 500,000	WALKER/WILLIAMS, 1980
250,000 - 450,000	COE, 1981
260,000 - 300,000	USGS, 1985
100,000 @ Capitola - 3,380,000 @ Pt. Santa Cruz	ORADIWE, 1986
160,000 - 190,000	GRIGGS, 1987
260,000 - 325,000	GRIGGS, 1990
325,000	BEST & GRIGGS, 1991

TABLE IV-2

SEDIMENT BUDGET TERMS

ESTIMATES FROM PRIOR STUDIES

WIND TRANSPORT

ESTIMATE (CY/YR/FT OF BEACH)	SOURCE
0.1 (MAXIMUM)	ORADIWE, 1986

DREDGING PRACTICES

ESTIMATE (CY/YR)	SOURCE
145,000 - 300,000	SCPD, ANNUAL REPORTS

ONSHORE/OFFSHORE

ESTIMATE (CY/YR)	SOURCE
ONSHORE = 2,000 OFFSHORE = 2,000	M&N, 1978
NO SIGNIFICANT ONSHORE/OFFSHORE	GRIGGS, 1990

LEAKAGE THROUGH VOIDS

ESTIMATE (CY/YR)	SOURCE
1,000 - EAST JETTY	M&N, 1978
20,000 - WEST JETTY	

TABLE IV-3
SUMMARY OF DREDGING AT SANTA CRUZ HARBOR

Date	Dredging Method	Estimated* Cubic Yards Dredged
1965	Single Phase	70,000
1966	Single Phase	34,000
1967	Single Phase	57,000
1968	Single Phase	60,500
1969	Single Phase	79,000
1970	Single Phase	94,700
1971	Single Phase	108,300
1972	Single Phase	90,000
1973	Single Phase	109,000
1974	Single Phase	60,000
1975	Single Phase	91,000
1976	Single Phase	98,000
1977	Jet Pump System	52,000
1977	Single Phase	147,000
1978	Jet Pump System	55,000
1979	Four Phase	162,000
1980	Four Phase	190,250
1981	Four Phase	187,687
1982	Two Phase	138,188
1983	Two Phase	154,498
1984	Two Phase	79,479
1985	Three Phase	145,237
1986	Four Phase	207,315
1987	Continuous	212,410
1988	Continuous	230,351
1989	Continuous	214,544
1990	Continuous	173,567
1991	Continuous	163,250
1992	Continuous	160,000

1. Estimates are pay quantities that probably underestimate actual dredge volumes, especially for single phase but not for continuous.

2. Estimated through mid March: Total quality expected to be 200,000 or greater.

V. SURGE

A. PREVIOUS WORK

Several studies have been conducted in the past on surge in Santa Cruz Harbor. However, most were completed prior to the expansion of the Harbor into the upper basin. In particular, the "Study on Surge Conditions in Santa Cruz Harbor" by V.J. Grauzinis, 1968 was very detailed. In addition, the Corps collected surge data from several gages in 1966 and 1967. Graphs of recorded wave heights and periods found in the Corps' files were reviewed. The three studies indicate that Santa Cruz harbor is susceptible to long period surge, with wave heights up to 2.5 feet. The predominate periods that have been recorded are grouped around 120 to 170 seconds as well as 650 to 700 seconds. The Marine Adviser's report indicates energy levels in the harbor as much as twice the energy offshore, implying that wave heights inside the harbor were up to 40 to 50 percent higher than those experienced offshore. The harbor appears to be able to attenuate the incoming energy of typical long period swell (16 to 22 seconds).

These studies were completed prior to construction of the upper harbor basis (Figure V-3). The Grauzinis report indicates that the seriousness of the surge problem should diminish after expansion of the harbor.

B. METHODOLOGY AND DATA USED

A detailed review of available reports on surge at Santa Cruz and within Monterey Bay was completed, as summarized above.

Discussions with the SCPD indicated that surge waves have caused significant damage to floats and berthed boats during extreme events. Also, surge action increases maintenance requirements for floats, boats, and berthing lines. Surge activity is most noticeable in the one to five minute period range. Some correlation with sets of larger waves impining the harbor entrance has been observed.

The SCPD provided information regarding the conditions of the harbor perimeter, observed surge periods, heights and wave forms, and the types and locations of damages. These data and data gained from previous studies were used to set-up and verify a computer model of harbor basin response to surge.

The governing equations adopted in the model were derived within the context of small amplitude, linear wave theory. It is assumed that the water depth within the basin is uniform and the friction effects are negligible.

The boundary element method (BEM) is used to solve the governing equations. In this approach, the boundary of the Harbor is discretized into a number of straight segments called boundary elements. The equations are solved for the discretized geometry to determine the

amplification of incident waves at pre-selected observation points in the basin. Amplification factor is determined as the ratio of the wave height at an observation point to the incident wave height offshore. Therefore, an amplification factor of unity means that the harbor does not amplify or attenuate the incident waves.

Calibration was accomplished in two steps. First, using data from previous reports, the model was calibrated to the initial configuration of the harbor (a single basin - Figure V-1). The model results compared well with the results of prior studies and field observations. Secondly, the base condition of the existing two basin configuration was tested. The model results compared well with field observations in terms of peak response periods (Figures V-2). While Figure V-2 shows several potential problem periods, available information indicates problems occur only in the one to five minute range. This is probably because incident wave energy is rare or very small in the longer period range. Subsequent analysis was therefore focused on the 1.7 and 3.7 minute peak periods. The accuracy of the model could be verified with surge data collected in the harbor, but none are available.

The model was used to evaluate the potential for entrance modifications to exasperate surge action within the harbor. Several alternative concepts to reduce harbor response to surge, or reduce damages, were developed. These alternatives were modeled and results were compared to those for the existing condition.

C. RESULTS

1. The basin configuration is the primary cause of long wave amplifications in the harbor. Santa Cruz Harbor is essentially a long, rectangular channel, closed at one end. Incoming wave energy is confined and has no chance to spread or dissipate. Existing rock structures along the boundaries have no absorbing effects on long period waves.

2. Deepening the entrance channel would have a negligible effect on basin response since the wave energy entering the basin will be the same. No other entrance modifications proposed by the Corps would have a noticeable effect on surge response of the harbor.

3. Extension of the west jetty or construction of an offshore breakwater would not have a measurable direct impact on the basin's long wave response, as long as the entrance width remains the same. The range of long wave lengths considered exhibit gradual water surface elevation fluctuations (similar to tidal fluctuations).

4. Several alternative approaches to reduce the surge problem in the harbor are discussed in the following and shown in Figure V-3. In general, solutions may be in the form of limiting long wave energy entering the harbor, or modifying the boundary conditions within the harbor. Results are summarized in Table V-1. The following discussion is based on a comparison of the maximum amplification factors computed

for the existing and the proposed configurations. It is recommended that the amplification factors at several additional points in the upper and lower basins be compared to illustrate the impact of the proposed wave barriers. Plots of amplification distribution throughout the basins should be reviewed and compared. A feasibility analysis of any of these alternatives should address navigation, sedimentation, and water quality issues.

> <u>Alternative A.</u> Construct a barrier to restrict the entrance channel width. This may be achieved by two solid structures, attached to the landward end of the jetties as shown in Figure V-3. This alternative provides a significant reduction in the magnitude of amplification factors for a response period of 1.7 minutes but only a small reduction in the amplification factors the of 3.7 minutes.

> <u>Alternatives B and C.</u> Constrict the flow area in the upper basin, near the narrowing between the upper and lower basins. Two different gap spacings were considered for the barrier between the basins; 180 feet (Alternative B) and 120 feet (Alternative C). The results indicate a moderate reduction in peak amplification.

> <u>Alternative D.</u> This is a combination of Alternatives A. and B. This Alternative reduces the peak response for both the 1.7 and 3.7 minute periods.

5. Several other actions could be taken to reduce damages and maintenance problems associated with surge. These alternatives were developed to address specific problem areas identified by the SCPD. These alternatives would likely involve lower costs, and are less likely to affect navigation, water quality and sedimentation. These alternatives are also identified in Figure V-3.

> <u>Alternative E.</u> Reconfigure the docks which presently expose boats to breaking waves and cross currents induced by long wave excitations. Previous damage reports along with the surge response pattern were used to identify potential problem spots.

> <u>Alternative F.</u> Realign the heavy, deep-draft boats moored at "X-dock." The results show that high current velocities are expected at this area where a nodal point will form at the second resonant period of 3.7 minutes. The present berth alignment orients boats so that surge-induced horizontal currents impinge against the beams. Reorienting the berths so that the boats are in line with the currents will substantially reduce the force impacted to the boat.

Alternative G. Dredge the problem spots, docks "X" and "I." Dredging around the "X-dock" would increase the channel cross-sectional area, which in turn will result in decreased current velocities. Similarly, deepening in the vicinity of "I-dock" would reduce the wave shoaling and decrease the incidence of wave breaking.

TABLE V-1
MAXIMUM SURGE AMPLIFICATION FACTOR AND ITS VARIATION
FROM THE EXISTING VALUE

Alternatives		Period = 1.7 min.		Period = 3.7 min.	
		Rmax	% Variation	Rmax	% Variation
	Existing Plan	8.3	-	16.8	-
A	Entrance Barrier	2.3	-72	15.9	-5
B	Barrier between the Basins 180 ft wide Gap	4.6	-45	14.5	-14
C	Barrier between the Basins 120 ft wide Gap	5.9	-29	13.9	-17
D	Both Barriers Alternatives A&B	3.1	-63	14.0	-17

Notes: Rmax is the maximum amplification factor.

VI. FINDINGS

1. Surveys and aerial photographs indicate that long-term trends in shoreline movements since the late 1970's are less than the seasonal and multi-year fluctuations in the vicinity of Santa Cruz Harbor. Accretion west of the harbor due to jetty construction appears to have stopped sometime between the late 1970's and early 1980's.

2. Accretion due to the Santa Cruz Harbor entrance jetties does not extend significantly west of the San Lorenzo River. This is based on a review of aerial photographs, which show only one shoreline offshore of the rock outcrop near the San Lorenzo River.

3. Shoreline position fluctuations are greater to the east of Santa Cruz Harbor than to the west. The greatest fluctuations are within 2,000 feet east of the east jetty, where dredged sand is discharged.

4. Dredging records indicate an increase in dredge volumes since the mid to late 1970's. Some increase is attributed to more frequent dredging, which has maintained the entrance open longer thereby capturing more sand. Some increase may also be related to the west fillet reaching its maximum extent by the early 1980's.

5. Potential eastward longshore sand transport rates are 24,000 to 48,000 cubic yards in one day and 85,000 cubic yards in four days. The potential westward transport is about 8,000 cubic yards in two days. These short-term rates are based on calculations using wave data, and are potential values accurate to within plus or minus 50 percent.

6. High shoaling rates associated with storm conditions/large swells have been documented at 11,000 cubic yards in one day. SCPD soundings indicated 15,000 cubic yards of shoaling over four days in November 1991. The SCPD considers this to be a moderate shoaling rate. Other extreme rates, based on dredging records, are 30,000 cubic yards in one month (average from 1970's) and 110,000 cubic yards in 2.5 months (1991-1992).

7. The harbor entrance can be shoaled by one storm event because the storage capacity of the channel is small relative to peak sand transport rates.

8. The channel dredged through the entrance shoal interrupts natural sand bypassing. More frequent dredging, while necessary to maintain a navigable entrance more often, results in a greater required dredge volume.

9. The updated sediment budget for the Santa Cruz Harbor entrance is shown in Figure IV-2.

10. Entrance modification alternatives identified by the Corps are not expected to noticeably affect surge conditions within Santa Cruz

Harbor.

11. Construction of walls that narrow the channels between the upper and lower harbors and near the harbor entrance would reduce peak surge action within the harbor. Additional investigation regarding the feasibility of these concepts is necessary.

12. Several actions have been identified that could reduce the damaging effects of surge by re-configuring berths and deepening in particular areas. Additional investigation regarding the feasibility of these concepts is necessary.

VII. REFERENCES

Grauzinis, V.J., "An Analysis of Seiche Conditions in Santa Cruz Harbor, California and Some Implications for The Proposed Harbor Extension", Prepared for the US Army Engineer District, San Francisco, Corps of Engineers. March 1968

Griggs, Gary B. & Best, Tim C., "The Santa Cruz Littoral Cell: Difficulties in Quantifying a Coastal Sediment Budget", Coastal Sediments, 1991

Griggs, Gary B. & Best, Tim C., "A Sediment Budget for the Santa Cruz Littoral Cell, Special Volume in Memory of F.D. Shepard (In Pres), 1990

Griggs, Gary B., "Investigation of the Disposal of Dredge Spoils from the Santa Cruz Small Craft Harbor", Final Report to the Santa Cruz Port Commission, August 15, 1991

Griggs, Gary B., "Littoral Drift Impoundment & Beach Nourishment in Northern Monterey Bay, California", Journal of Coastal Research Special Issue No. 6, Summer 1990

Griggs, Gary B. & Johnson, R.E., "Effects of the Santa Cruz Harbor on Coastal Processes of Northern Monterey Bay, California", Environmental Geology Vol. 1, 1976, pp. 299-312

Griggs, Gary B., "Littoral Cells & Harbor Dredging Along the California Coast", Environmental Geology & Water Science, Vol. 10 No. 1, 1987, pp. 7-20

Griggs, Gary B., "The Production, Transport and Delivery of Coarse Grained Sediment by California's Coastal Streams", Coastal Sediments, 87, 1987, pp. 1825-1838

Marine Advisers, Inc., " A Sea-Swell Recording Study at Santa Cruz, California", for the US Army Engineer District, San Francisco, Corps of Engineers, Nov. 1964

Moffatt & Nichol, Engineers, "Santa Cruz Harbor Shoaling Study", for the US Army Engineer District, San Francisco, Corps of Engineers, June 1978, 176 pp.

Oradiwe, Emmanuel, "Sediment Budget for Monterey Bay", Masters Thesis, Naval Post Graduate School, Monterey, California, March 1986, 101 pp.

Santa Cruz Port District, "Annual Dredging Reports", Prepared by The Santa Cruz Port District, Santa Cruz, California, 1986, 1987, 1988, 1989, 1990

US Army Corps of Engineers, San Francisco District, "Letter to Leon E. Paneta, House of Representatives", Nov., 1981, 4 pp.

US Geological Survey, "Geomorphology Framework Report, Monterey Bay", Prepared for US Army Corps of Engineers, Los Angeles District, Dec. 1985, 97 pp.

US Army Corps of Engineers, "San Lorenzo River Sedimentation Study", Prepared by the Waterways Experiment Station, Vicksburg, Mississippi, Dec. 1986, 47 pp.

Science Engineering Associates, "Feasibility Study for a Surge Action Model of Monterey Harbor, California", Prepared for US Army Engineer District, San Francisco, California, Corps of Engineers, October, 1965

US Army Corps of Engineers, Data Obtained from 3 ring binder titled: <u>Wave Studies, Santa Cruz Harbor</u>, 1966, 11 pp.

US Army Corps of Engineers, "Santa Cruz S_{xy}, 1978-1982", 1991

US Army Corps of Engineers, "Prototype Stability Study of Quadripad Units at West Jetty, Santa Cruz Harbor, Santa Cruz California", Aug. 1971, 15 pp.

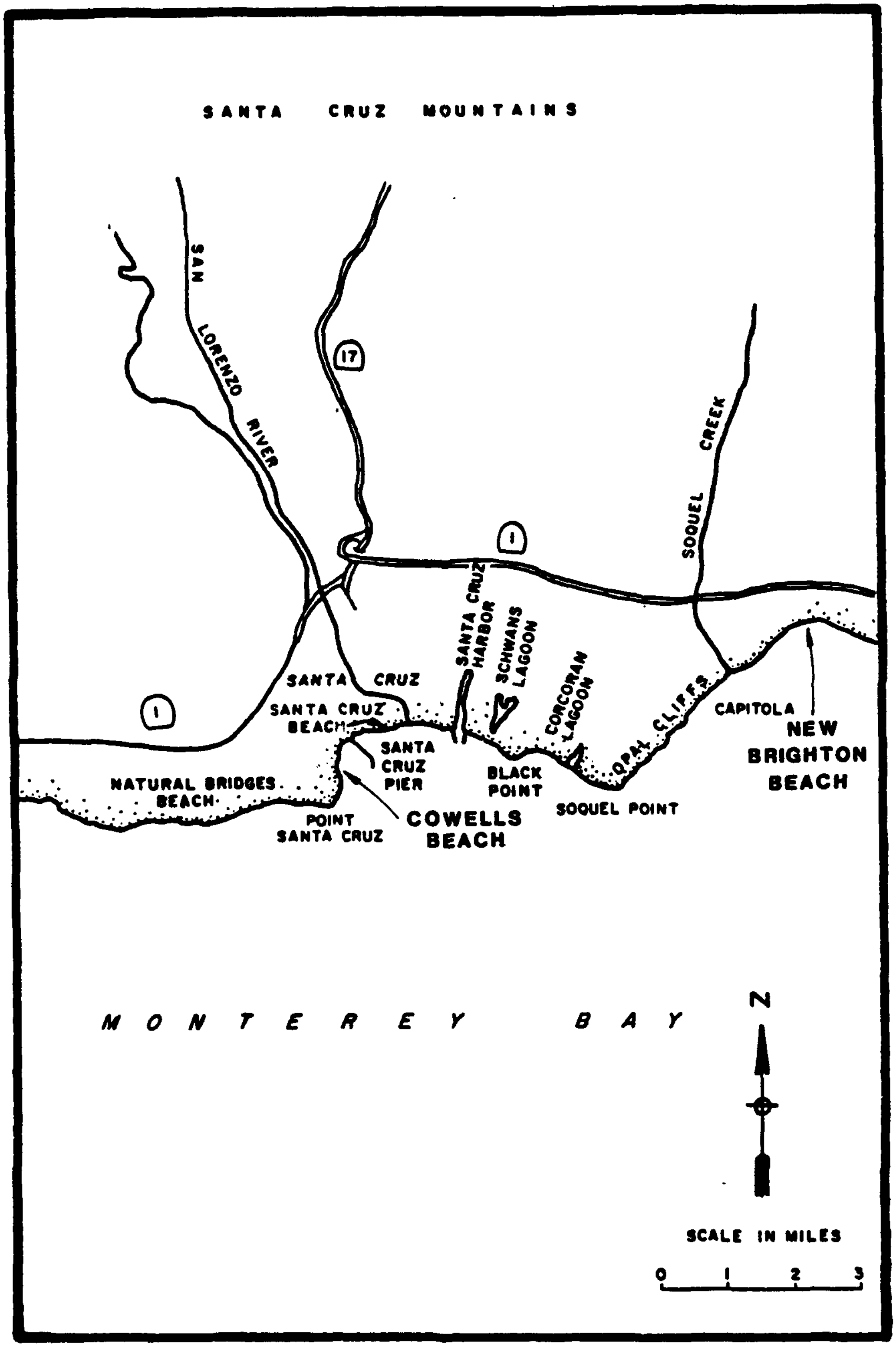
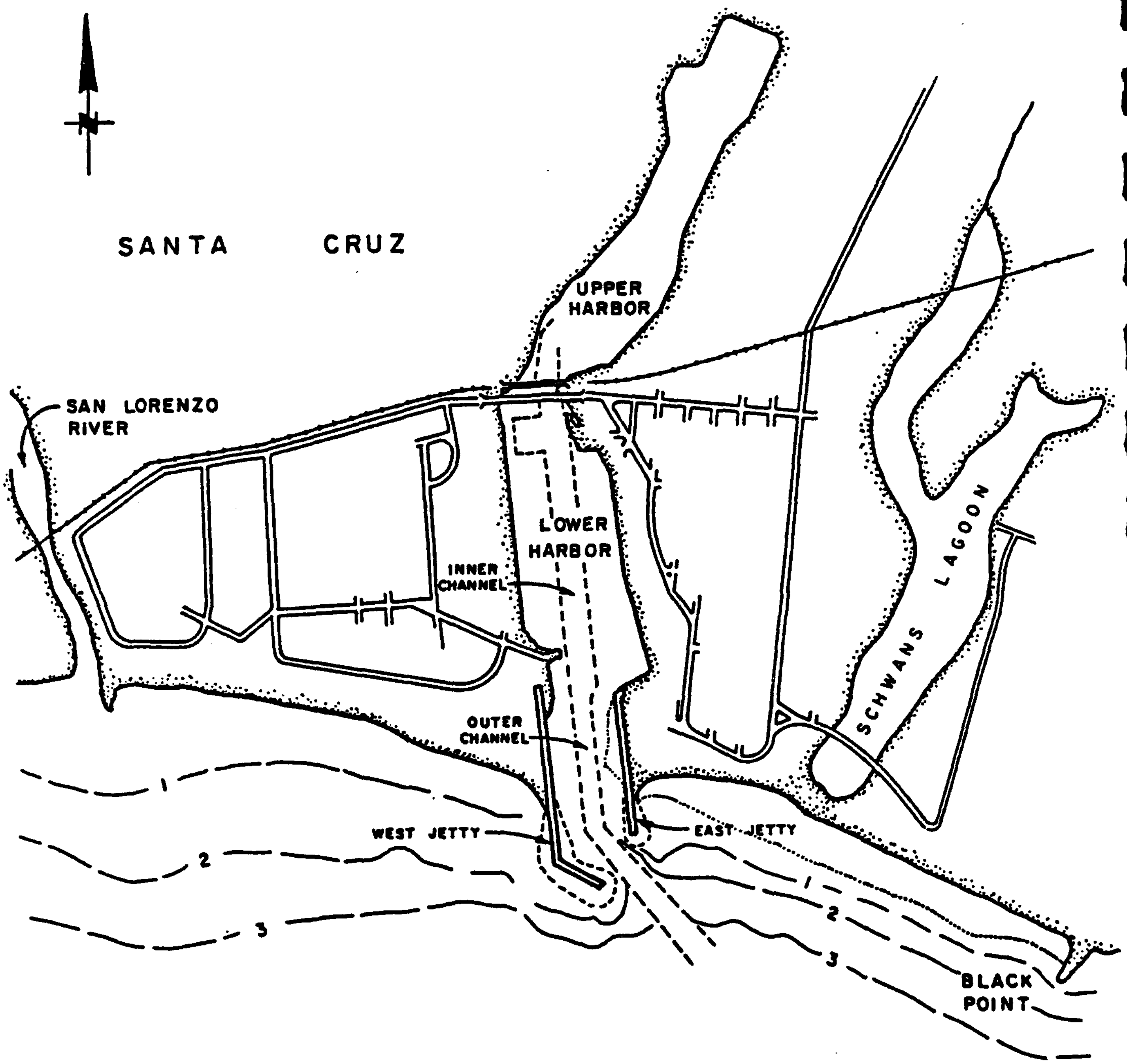


FIG. I-1 SANTA CRUZ VICINITY MAP



---- 3 ---- depth in fathoms below MLLW

SCALE: 1:10,000

FIG. I-2 SANTA CRUZ SMALL-CRAFT HARBOR

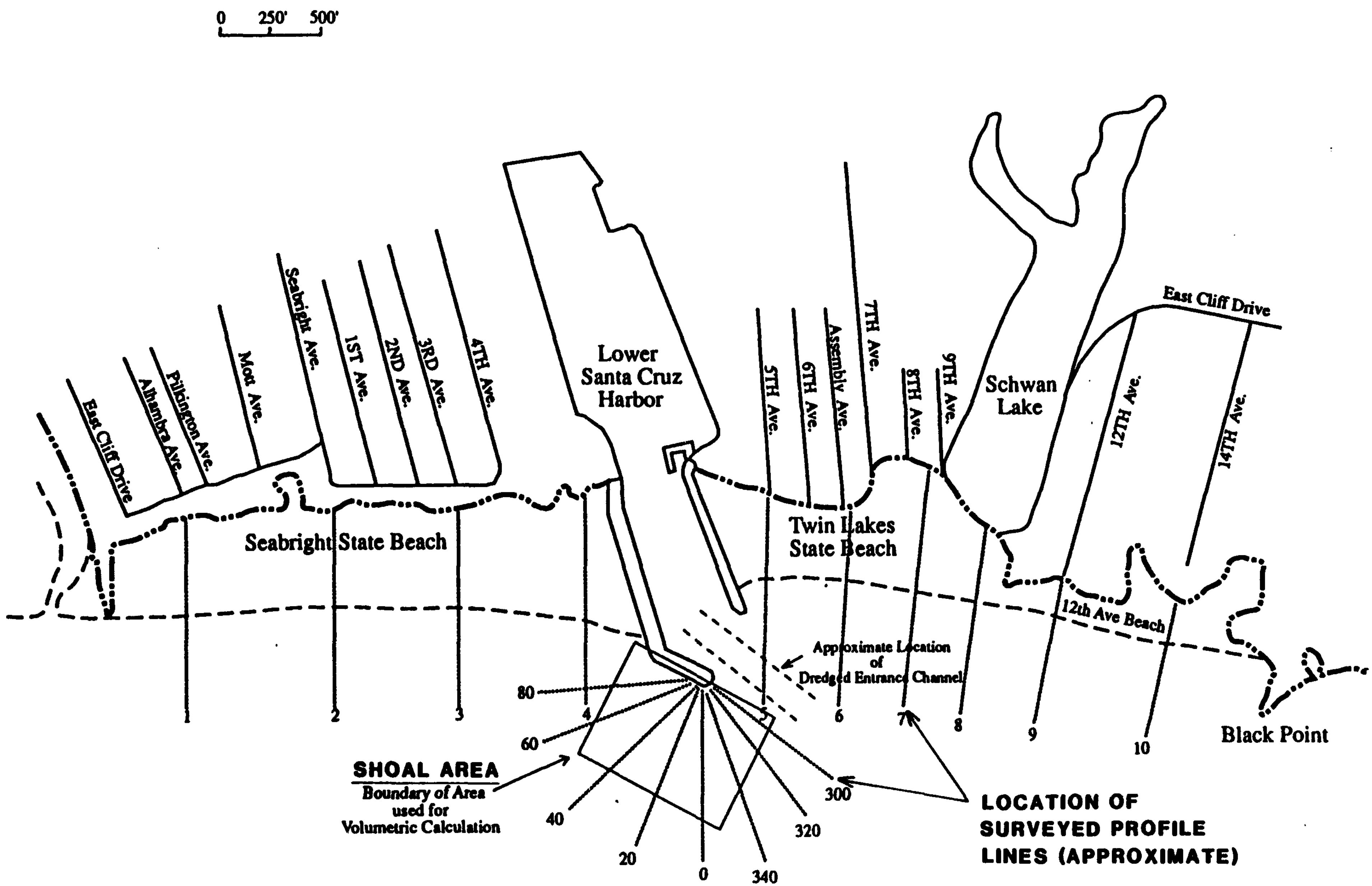


FIGURE II-1: SURVEYED BEACH AND SHOAL PROFILE LINES

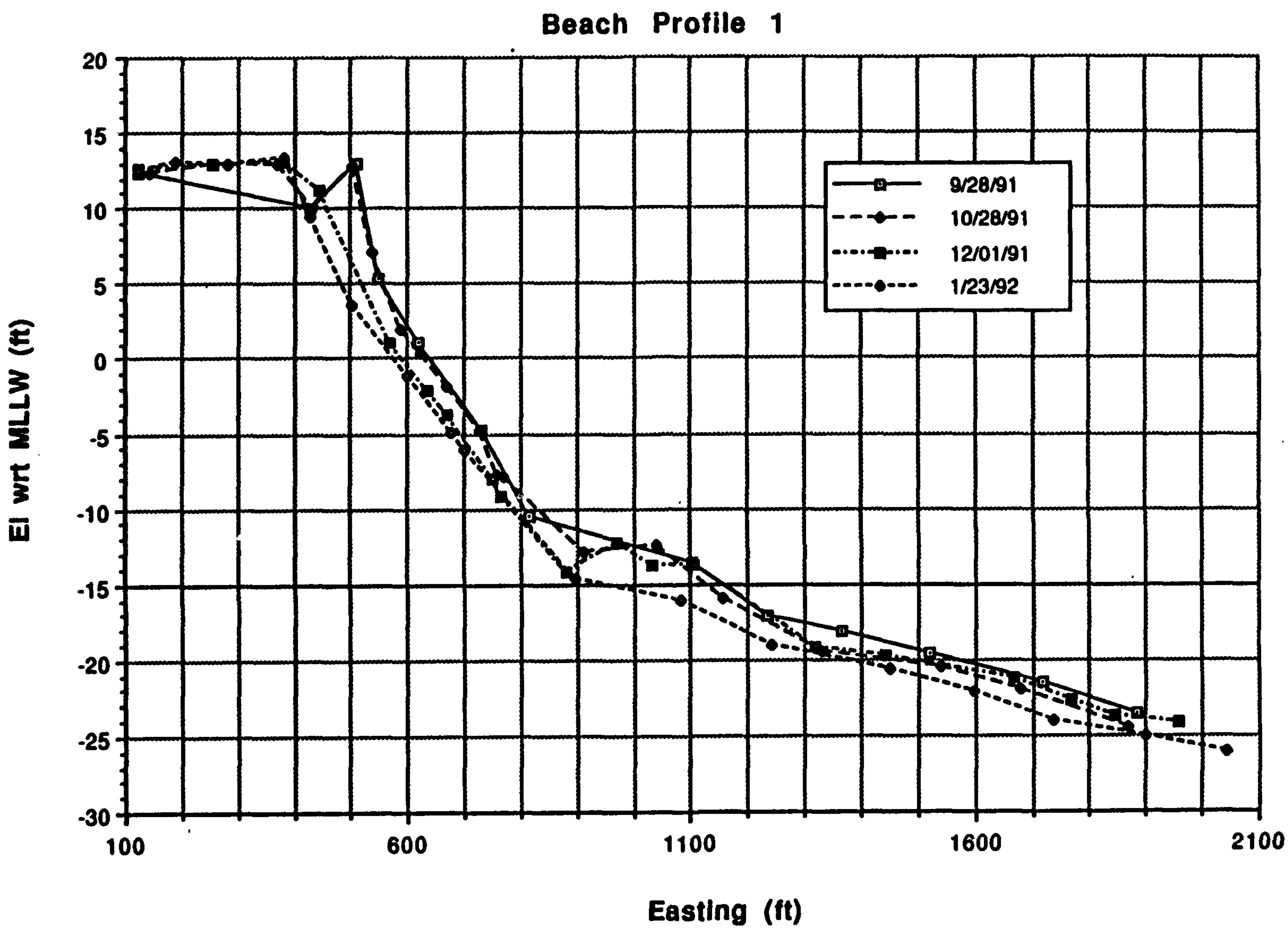

Beach Profile 1
El wrt MLLW (ft)
Easting (ft)
9/28/91
10/28/91
12/01/91
1/23/92
20
15
10
5
0
-5
-10
-15
-20
-25
-30
100
600
1100
1600
2100

FIGURE II-2

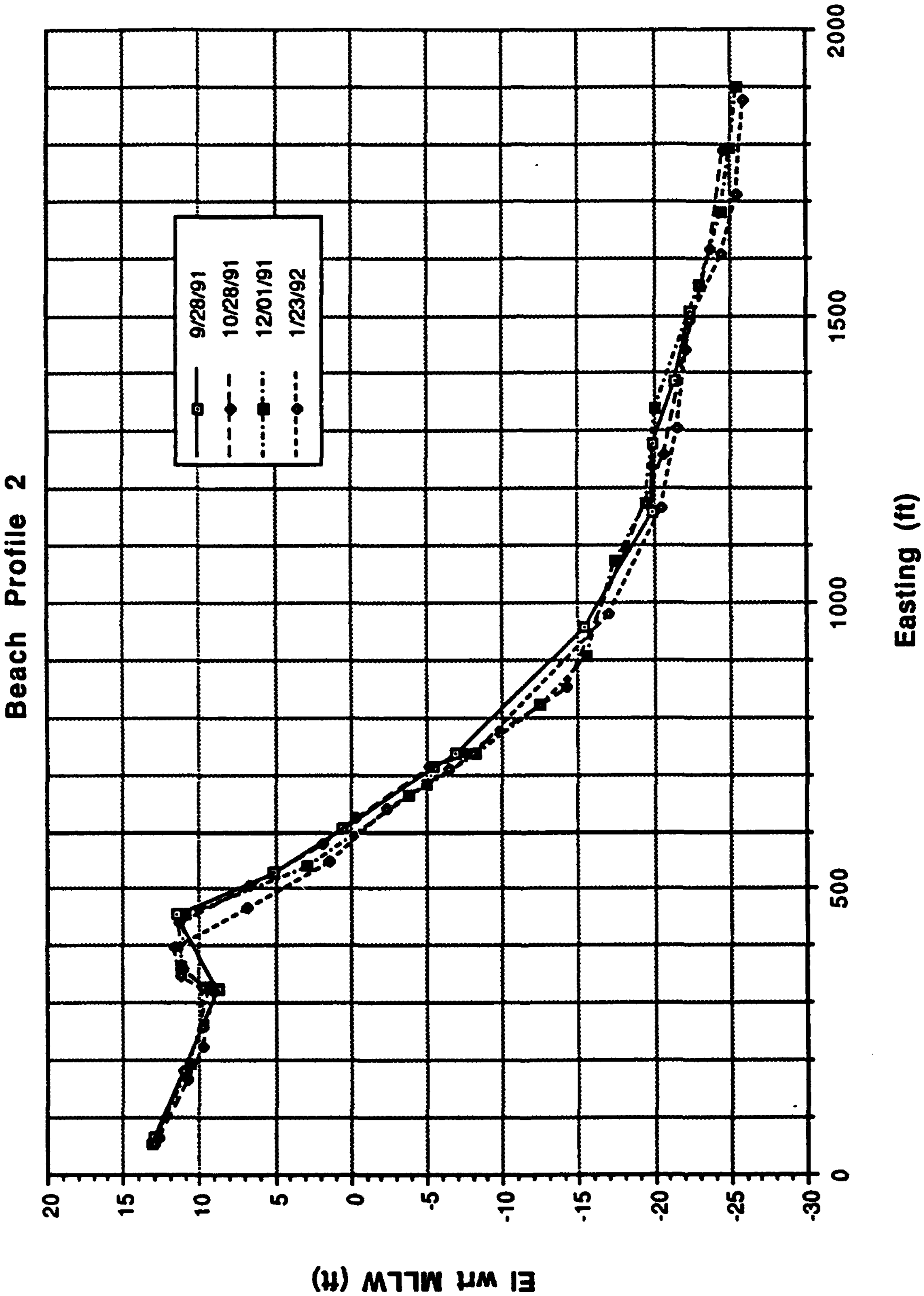
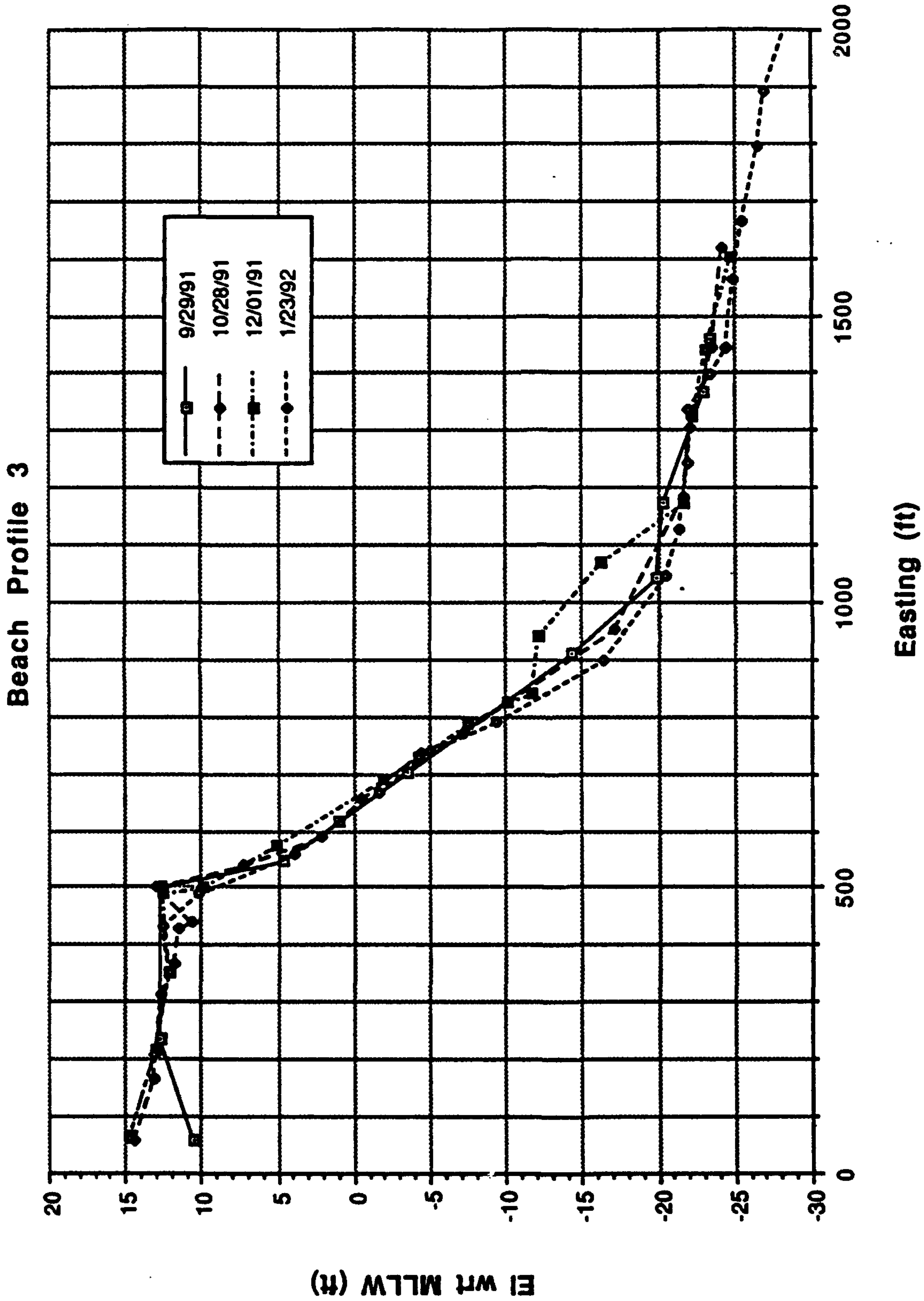

Beach Profile 2
9/28/91
10/28/91
12/01/91
1/23/92
El wrt MLLW (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
Easting (ft)
0
500
1000
1500
2000

FIGURE II-3



Beach Profile 3
9/29/91
10/28/91
12/01/91
1/23/92
El wrt MLLW (ft)
Easting (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000

FIGURE II-4

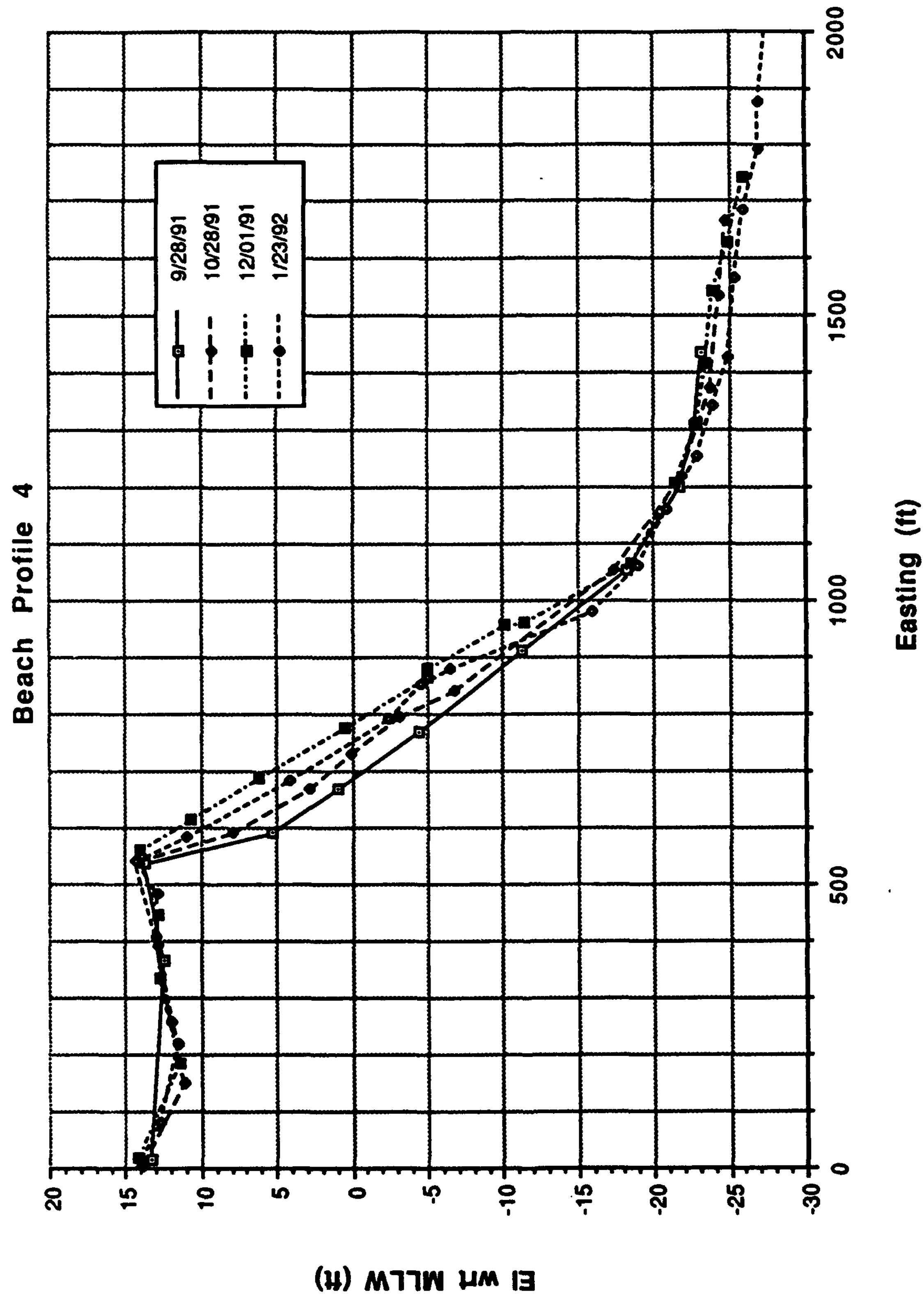

Beach Profile 4
9/28/91
10/28/91
12/01/91
1/23/92
El wrt MLLW (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
Easting (ft)

FIGURE II-5

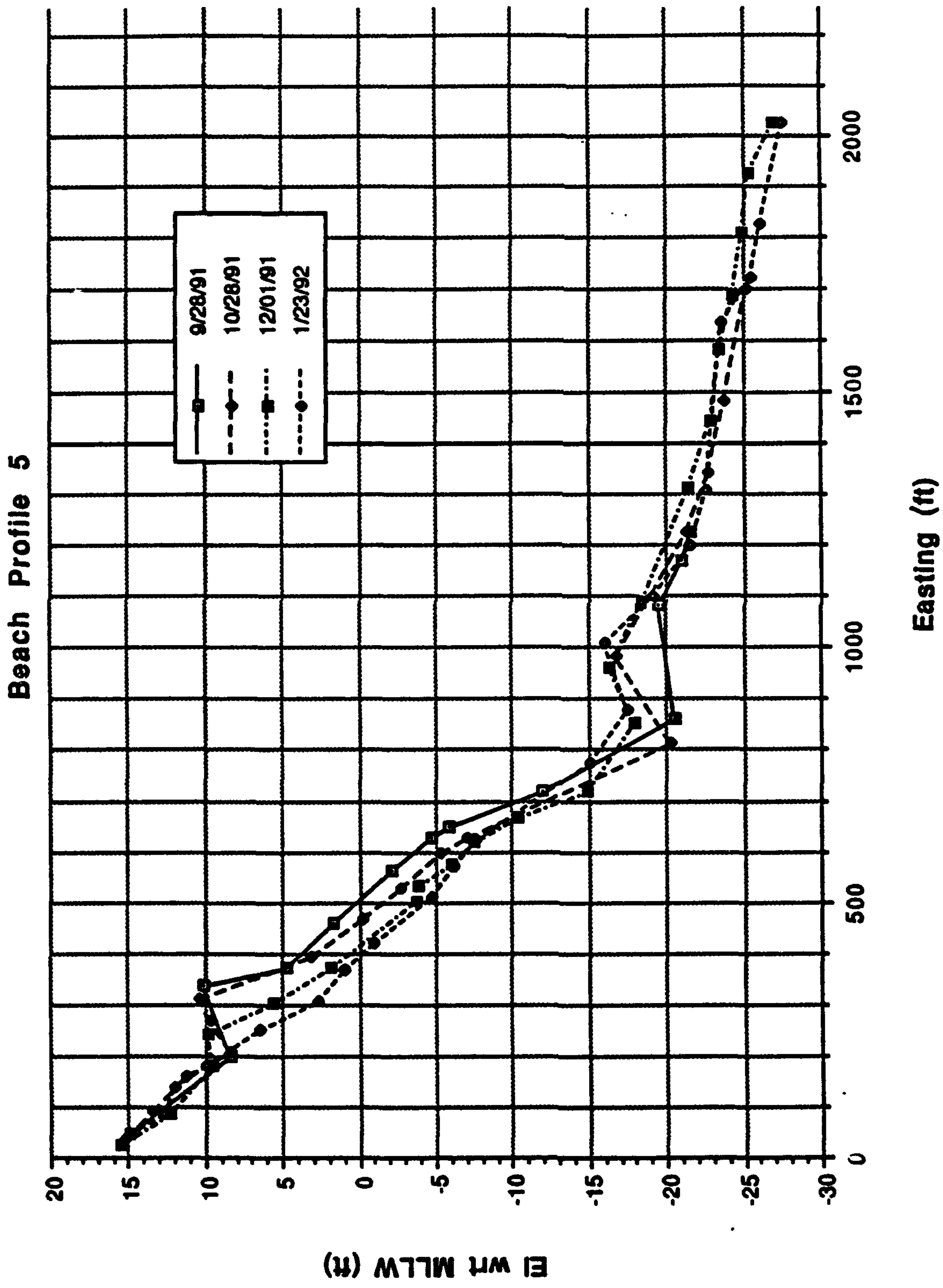

Beach Profile 5
9/28/91
10/28/91
12/01/91
1/23/92
El wrt MLLW (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
Easting (ft)

FIGURE II-6

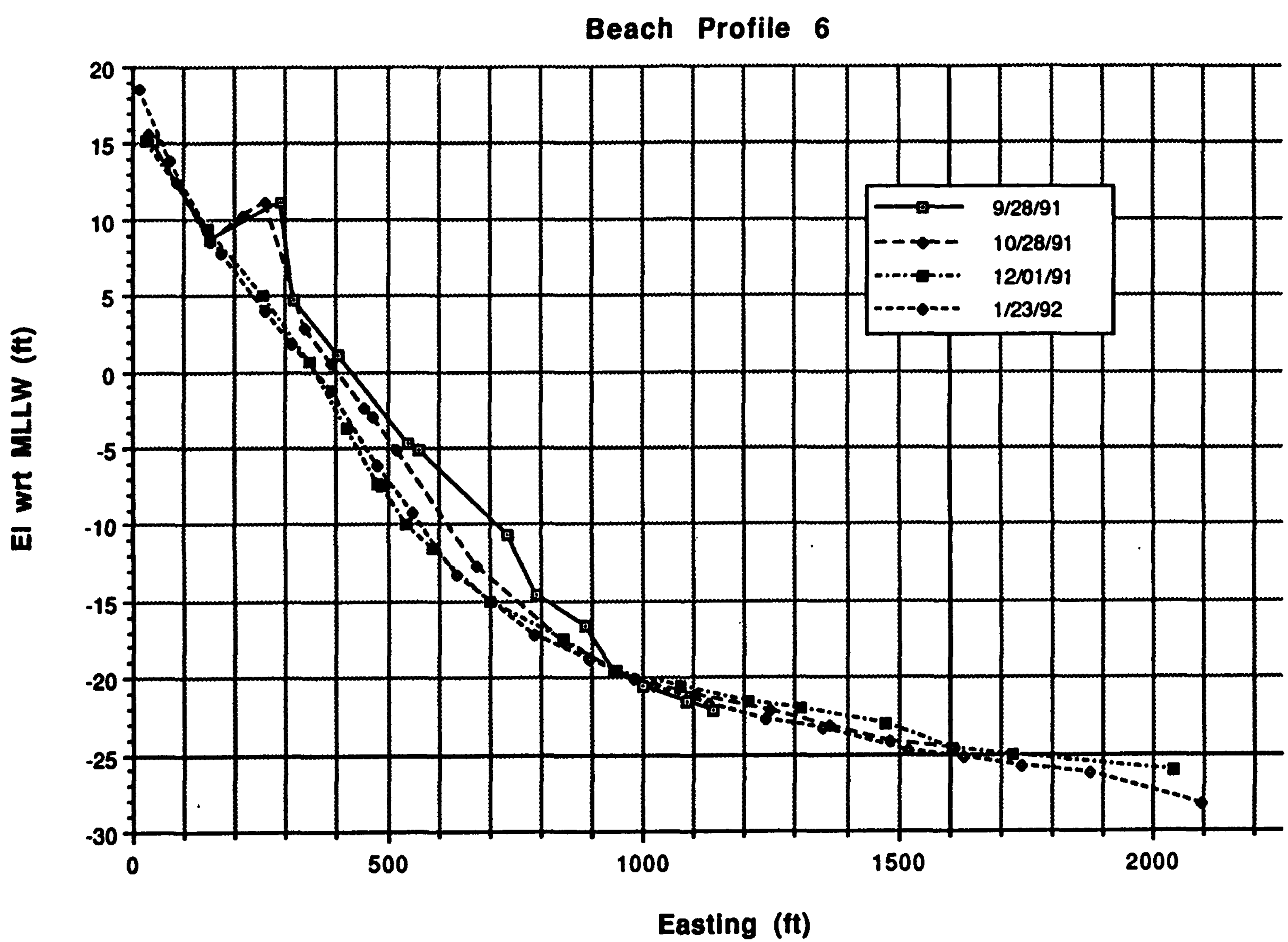
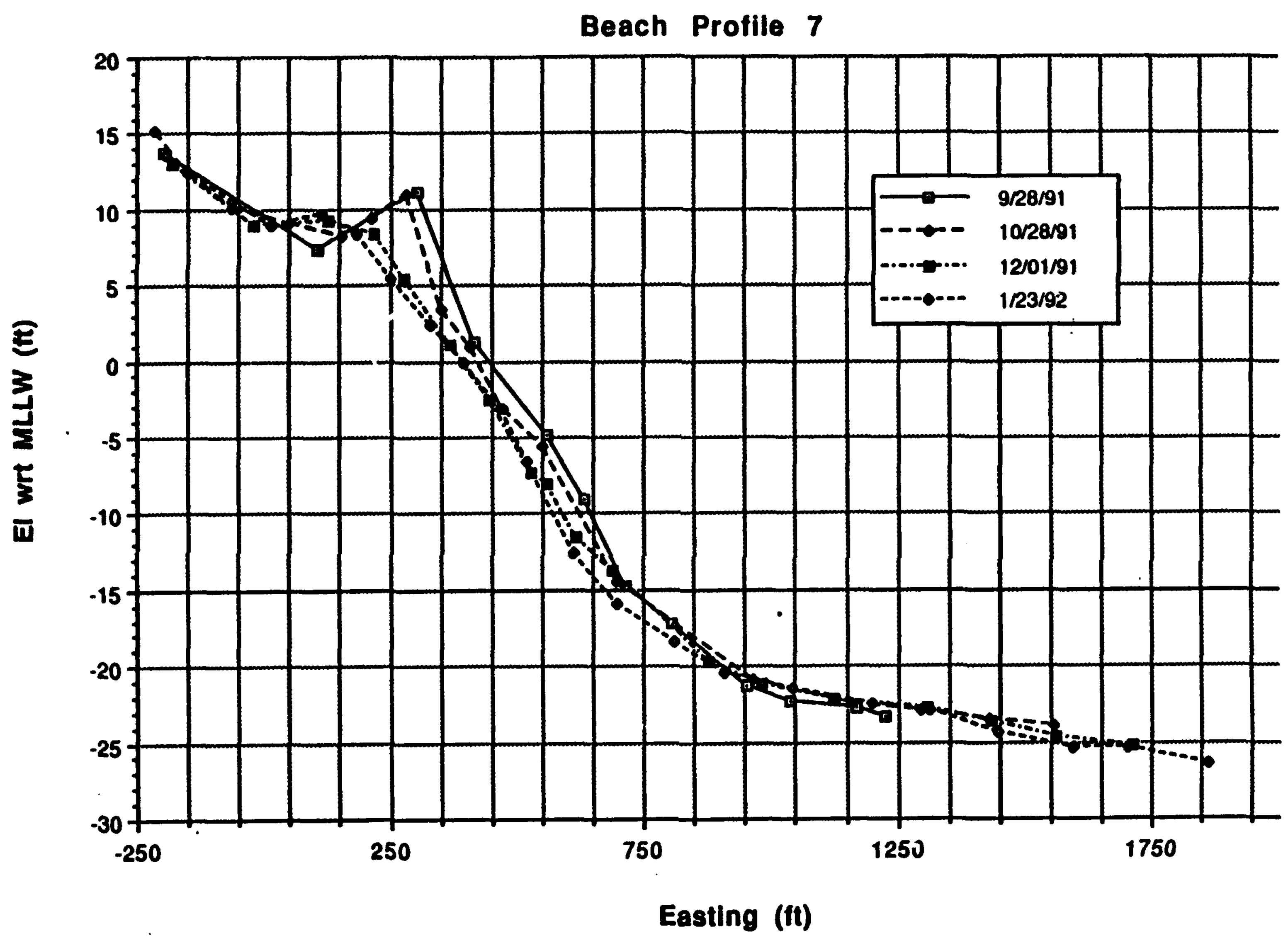
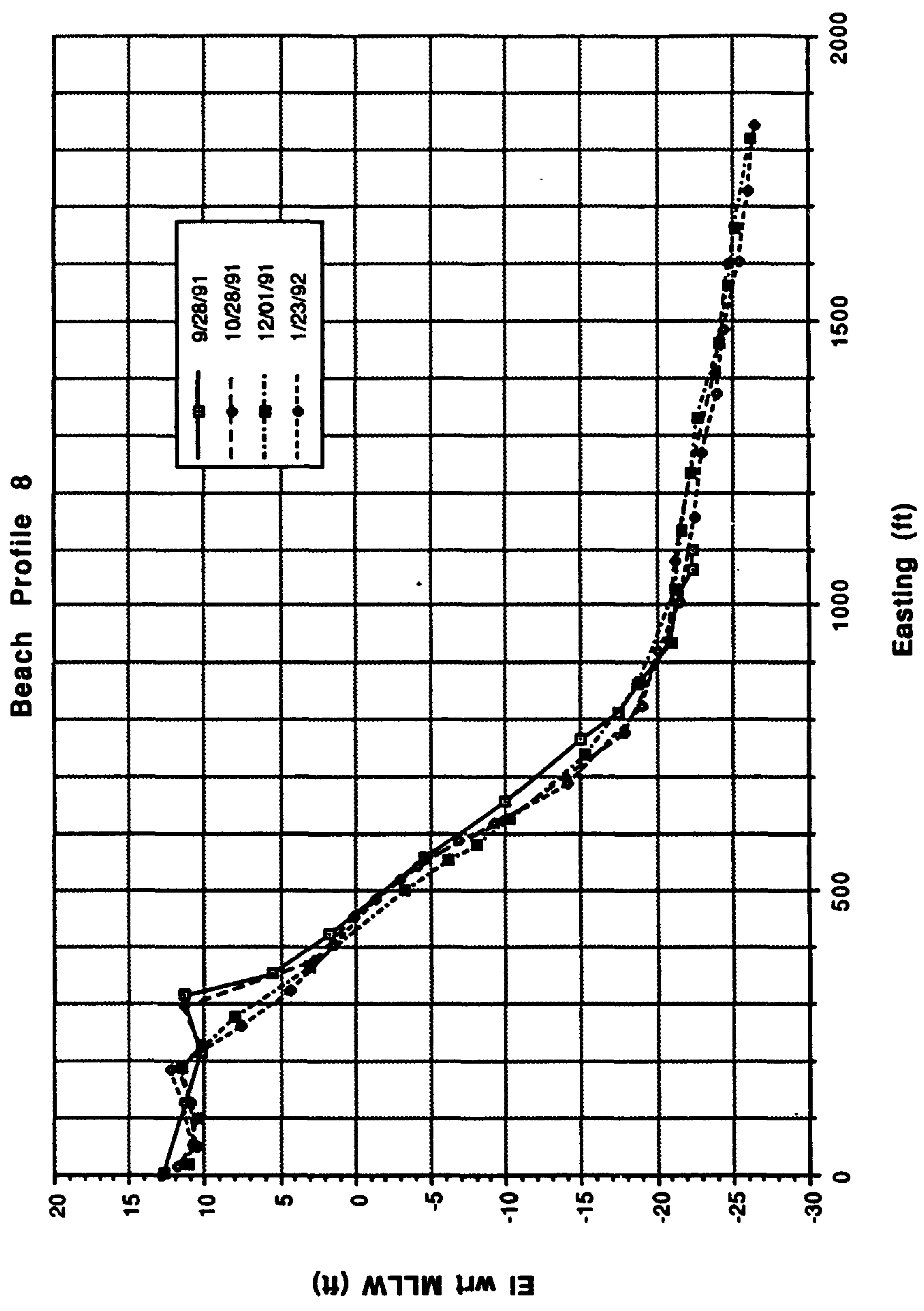

Beach Profile 6
9/28/91
10/28/91
12/01/91
1/23/92
El wrt MLLW (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
Easting (ft)

FIGURE II-7



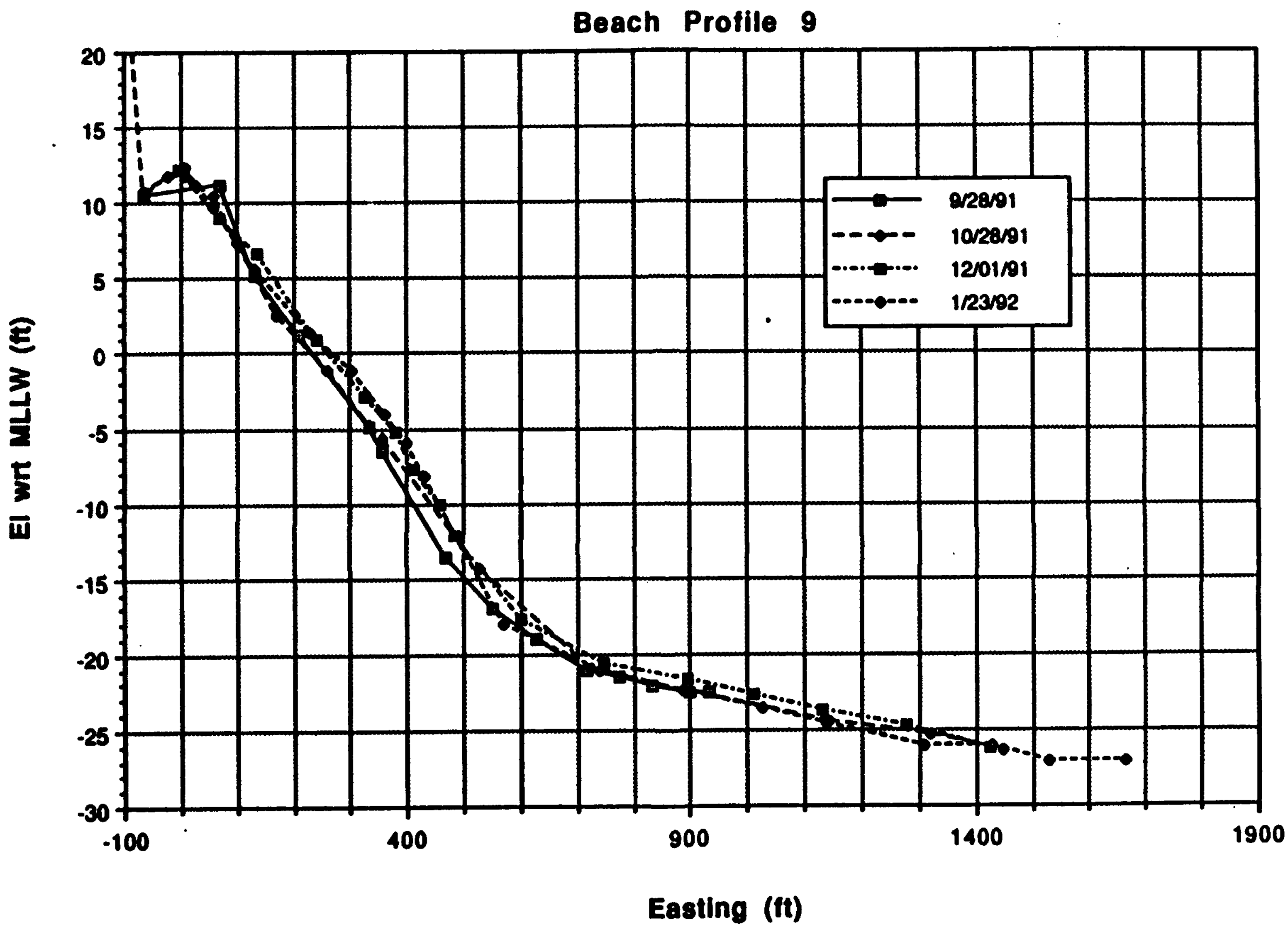
Beach Profile 7
9/28/91
10/28/91
12/01/91
1/23/92
El wrt MLLW (ft)
Easting (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-250
250
750
1250
1750

FIGURE II-8



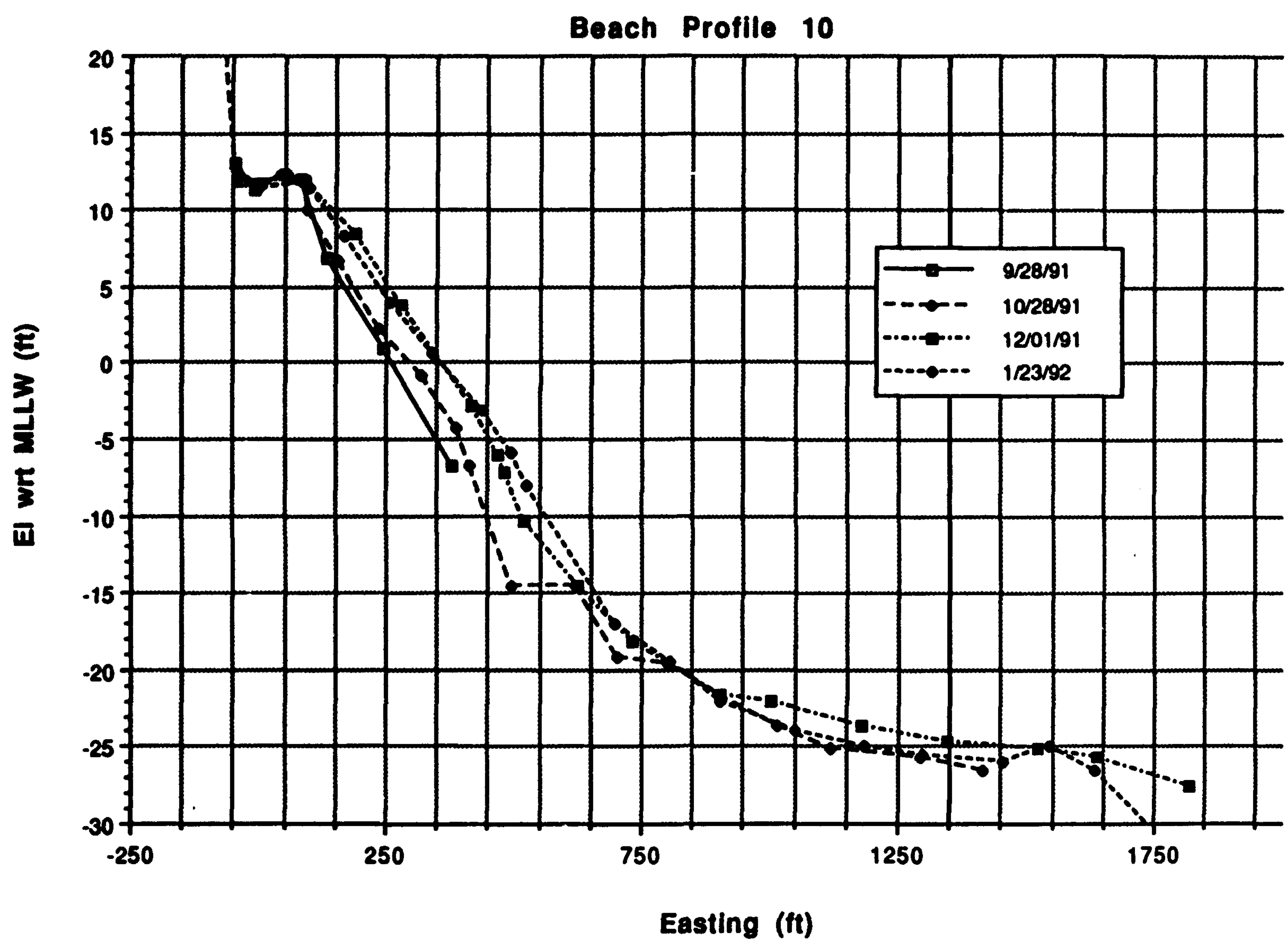
Beach Profile 8
9/28/91
10/28/91
12/01/91
1/23/92
El wrt MLLW (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
Easting (ft)
0
500
1000
1500
2000

FIGURE II-9



Beach Profile 9
9/28/91
10/28/91
12/01/91
1/23/92
El wrt MLLW (ft)
Easting (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-100
400
900
1400
1900

FIGURE II-10



Beach Profile 10
El wrt MLLW (ft)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-250
250
750
1250
1750
Easting (ft)
9/28/91
10/28/91
12/01/91
1/23/92

FIGURE II-11

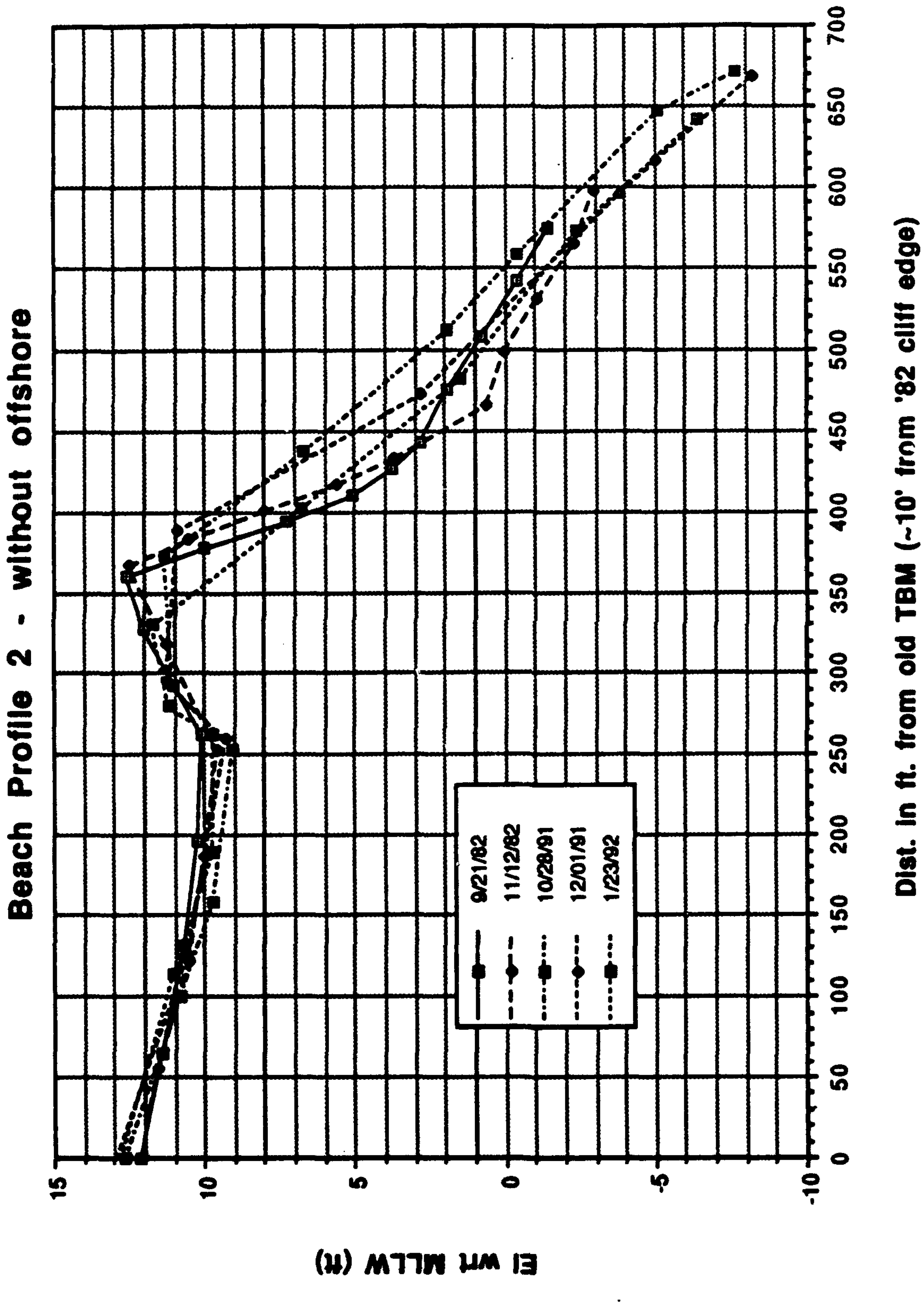
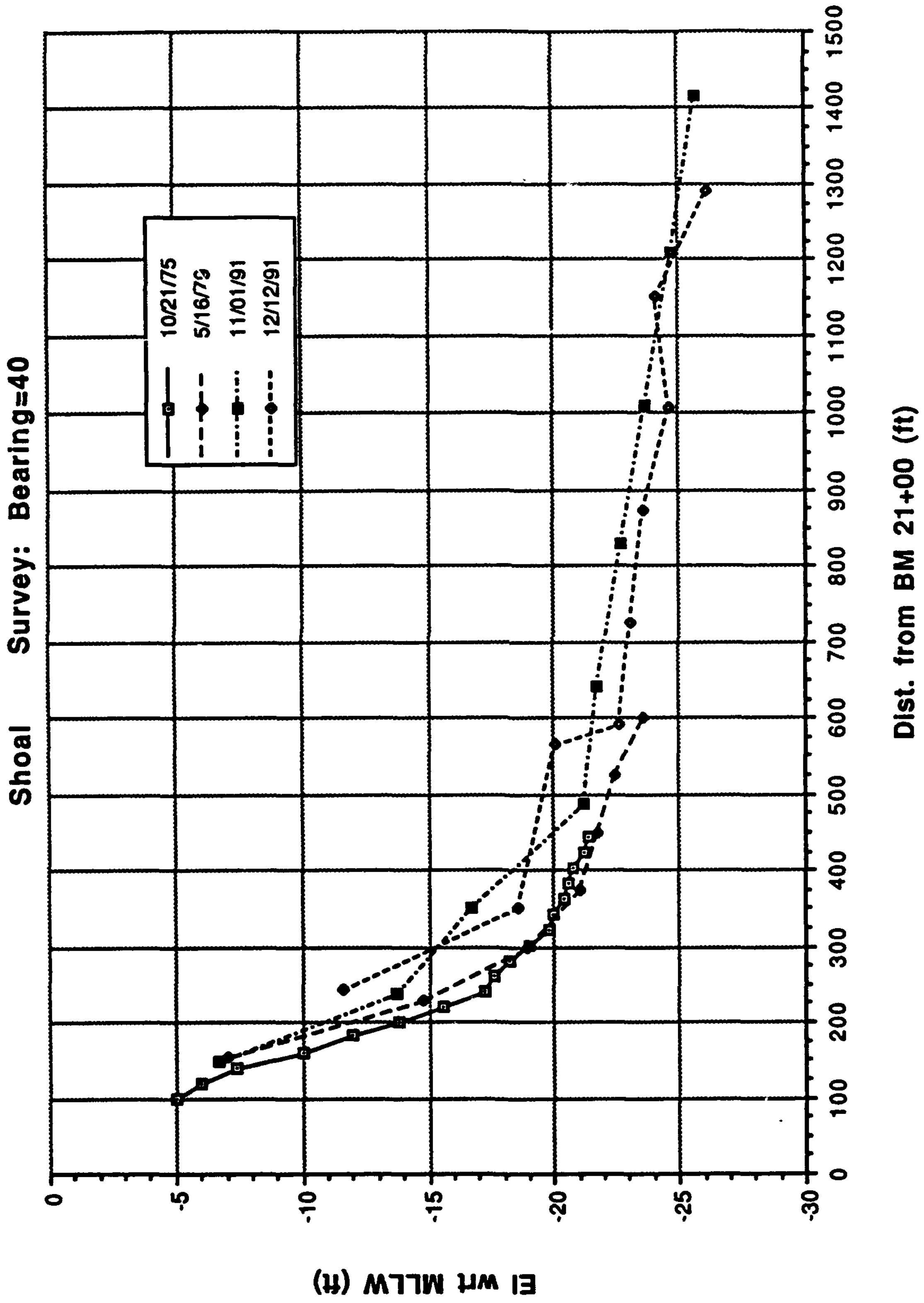
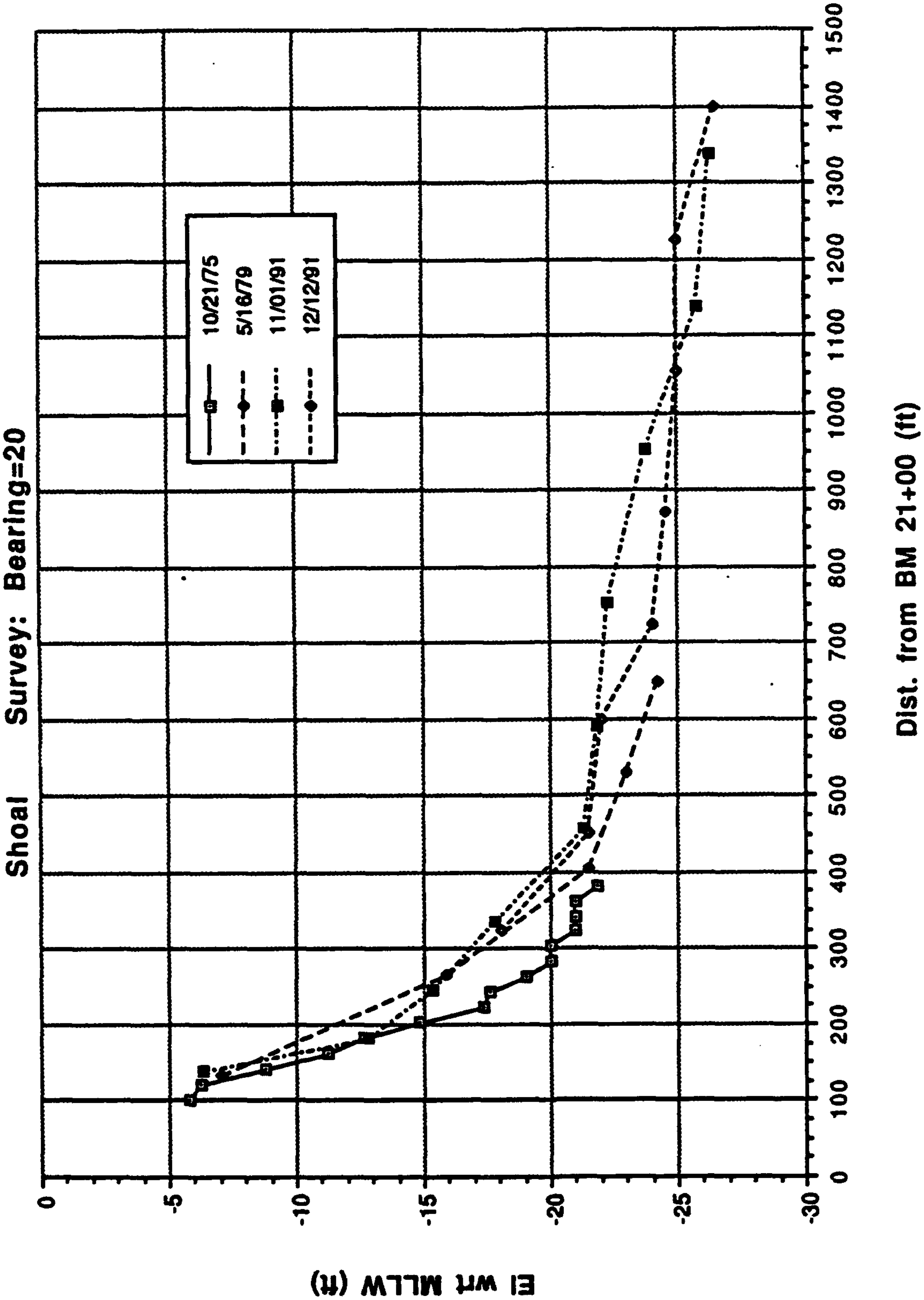

Beach Profile 2 - without offshore
El wrt MLLW (ft)
15
10
5
0
-5
-10
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Dist. in ft. from old TBM (~10' from '82 cliff edge)
9/21/82
11/12/82
10/28/91
12/01/91
1/23/92

FIGURE II-12



Shoal Survey: Bearing=40
10/21/75
5/16/79
11/01/91
12/12/91
El wrt MLLW (ft)
0
-5
-10
-15
-20
-25
-30
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Dist. from BM 21+00 (ft)

FIGURE II-13



Shoal Survey: Bearing=20
10/21/75
5/16/79
11/01/91
12/12/91
El wrt MLLW (ft)
0
-5
-10
-15
-20
-25
-30
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Dist. from BM 21+00 (ft)

FIGURE II-14

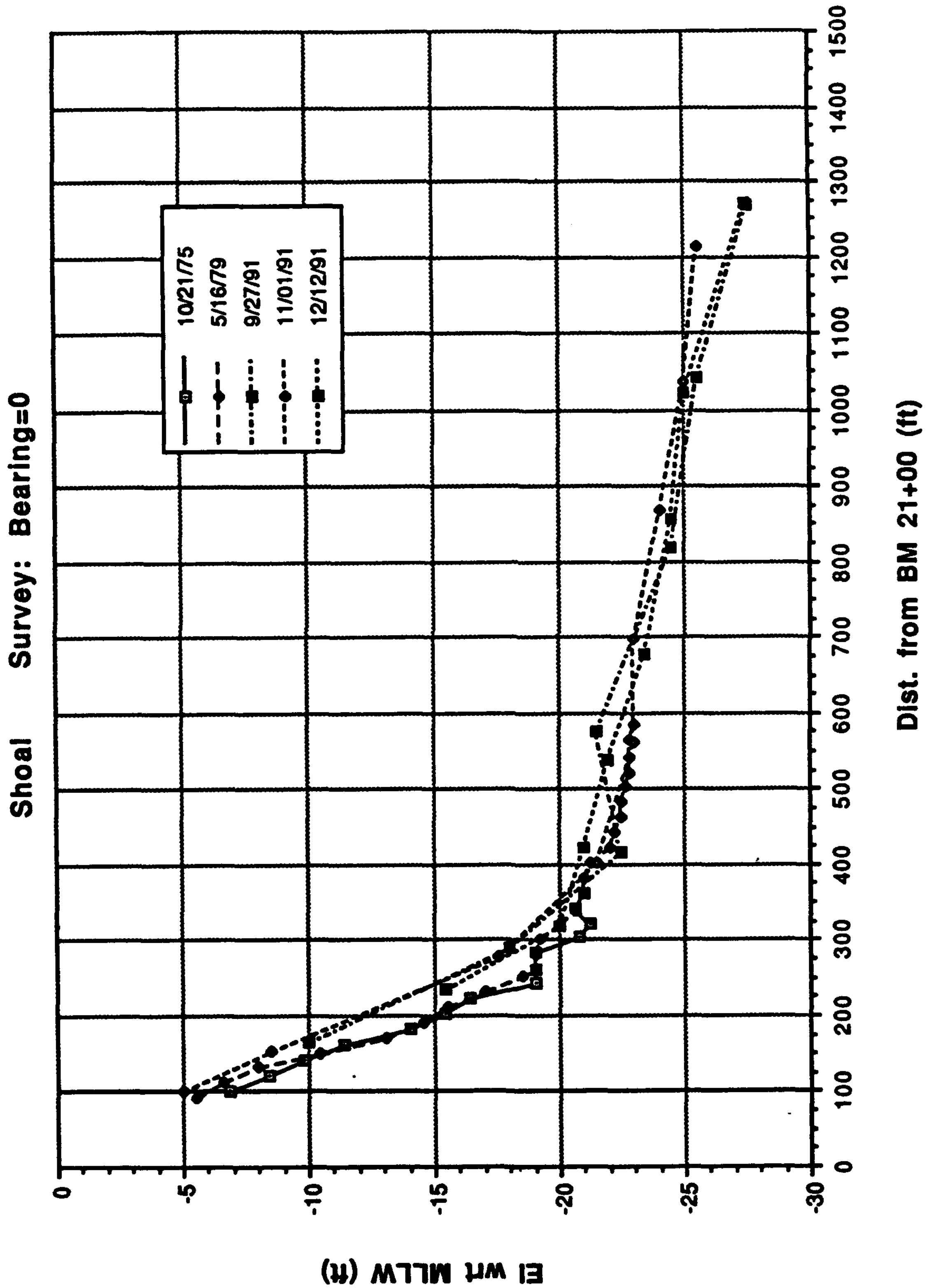

Shoal Survey: Bearing=0
10/21/75
5/16/79
9/27/91
11/01/91
12/12/91
El wrt MLLW (ft)
Dist. from BM 21+00 (ft)
0
-5
-10
-15
-20
-25
-30
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

FIGURE II-15

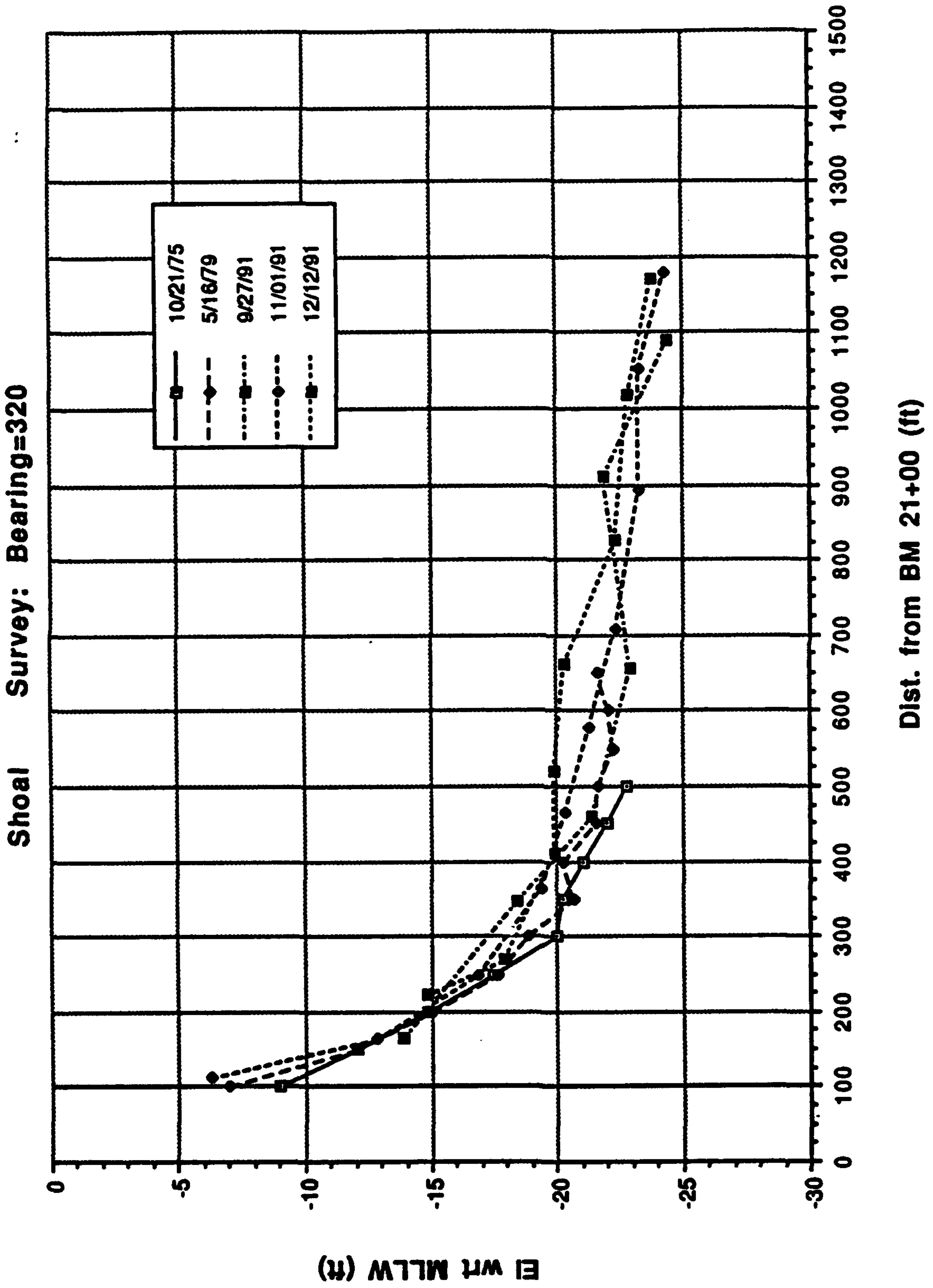

Shoal Survey: Bearing=320
10/21/75
5/16/79
9/27/91
11/01/91
12/12/91
El wrt MLLW (ft)
Dist. from BM 21+00 (ft)
0
-5
-10
-15
-20
-25
-30
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

FIGURE II-16

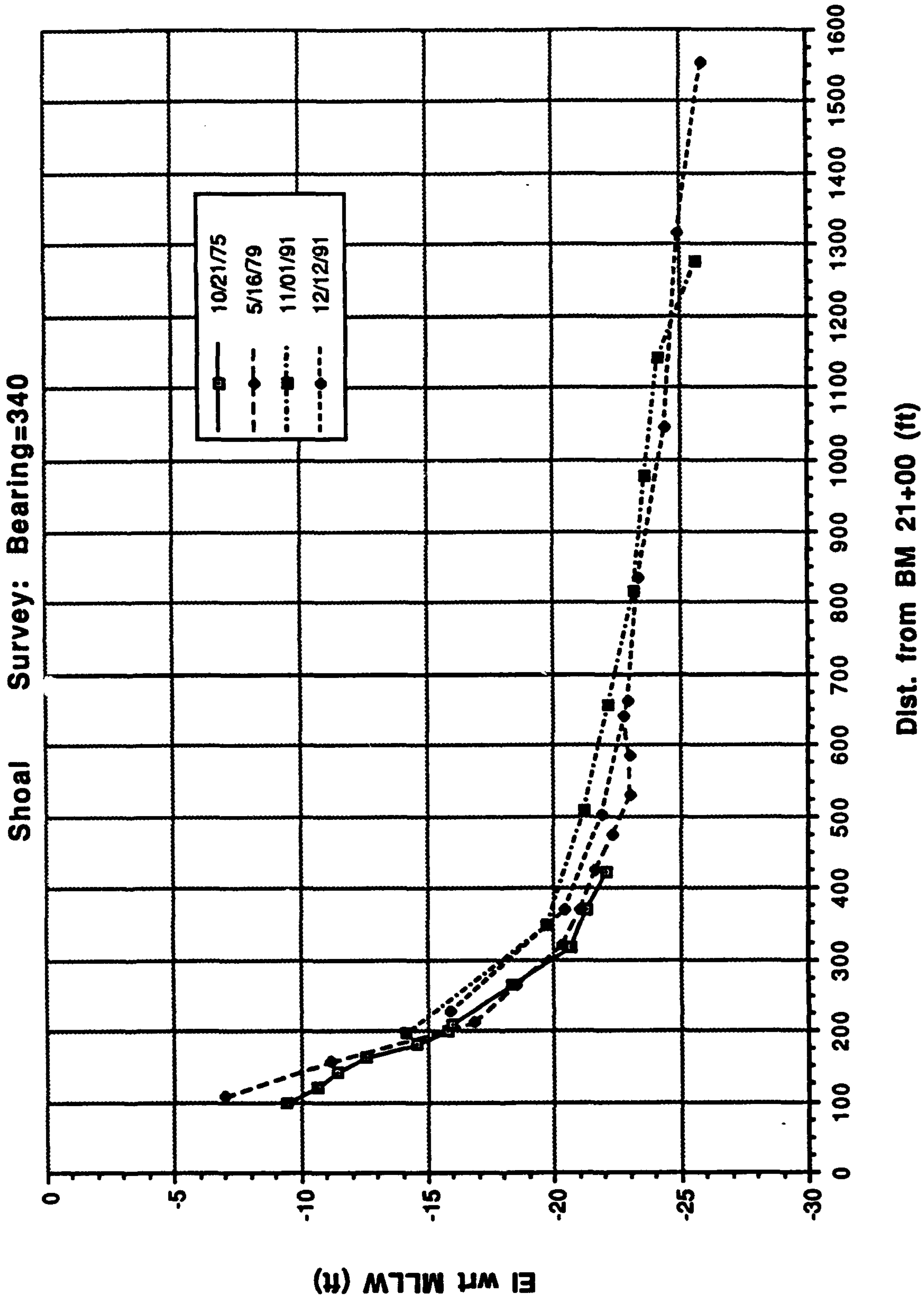
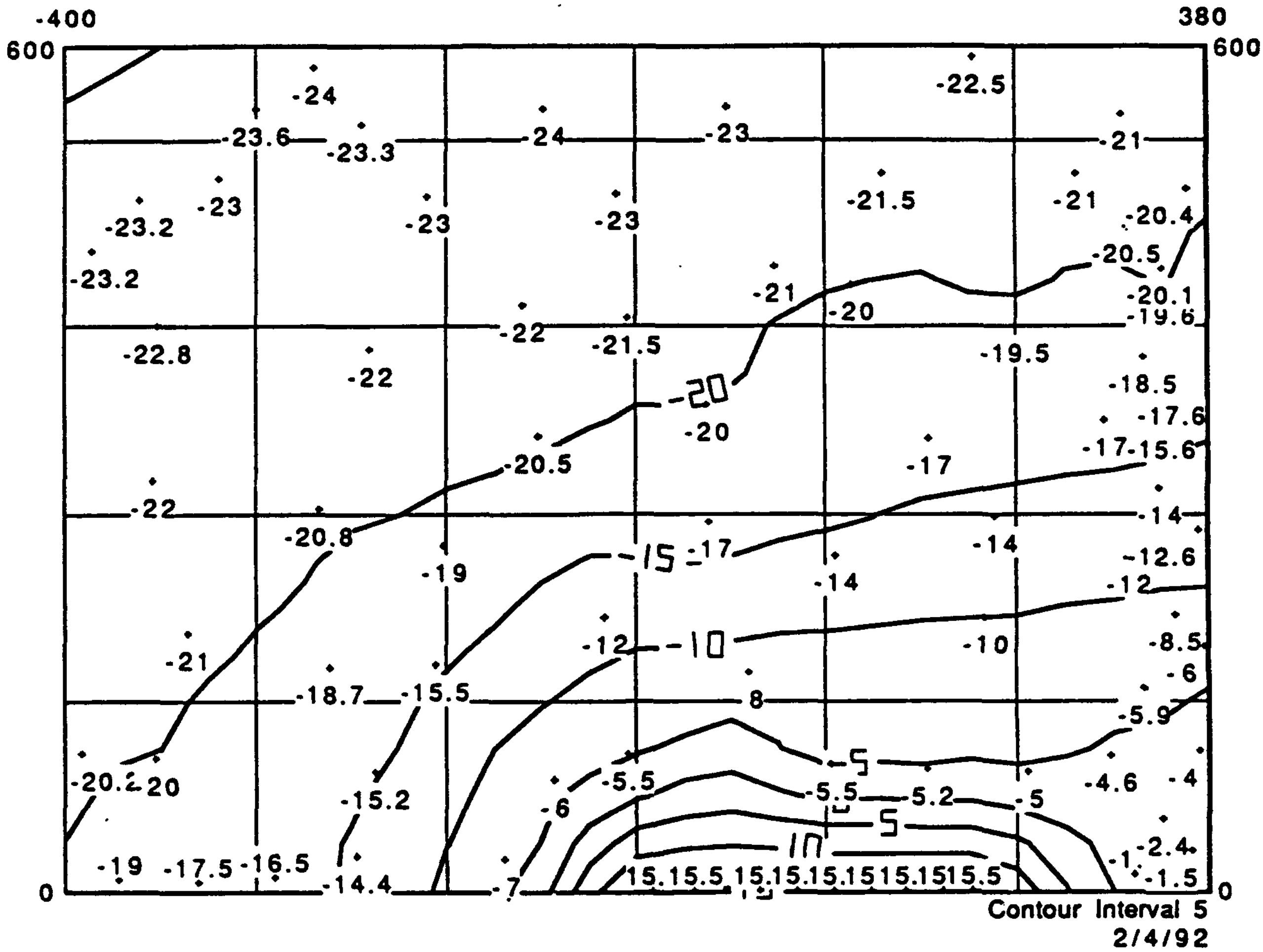
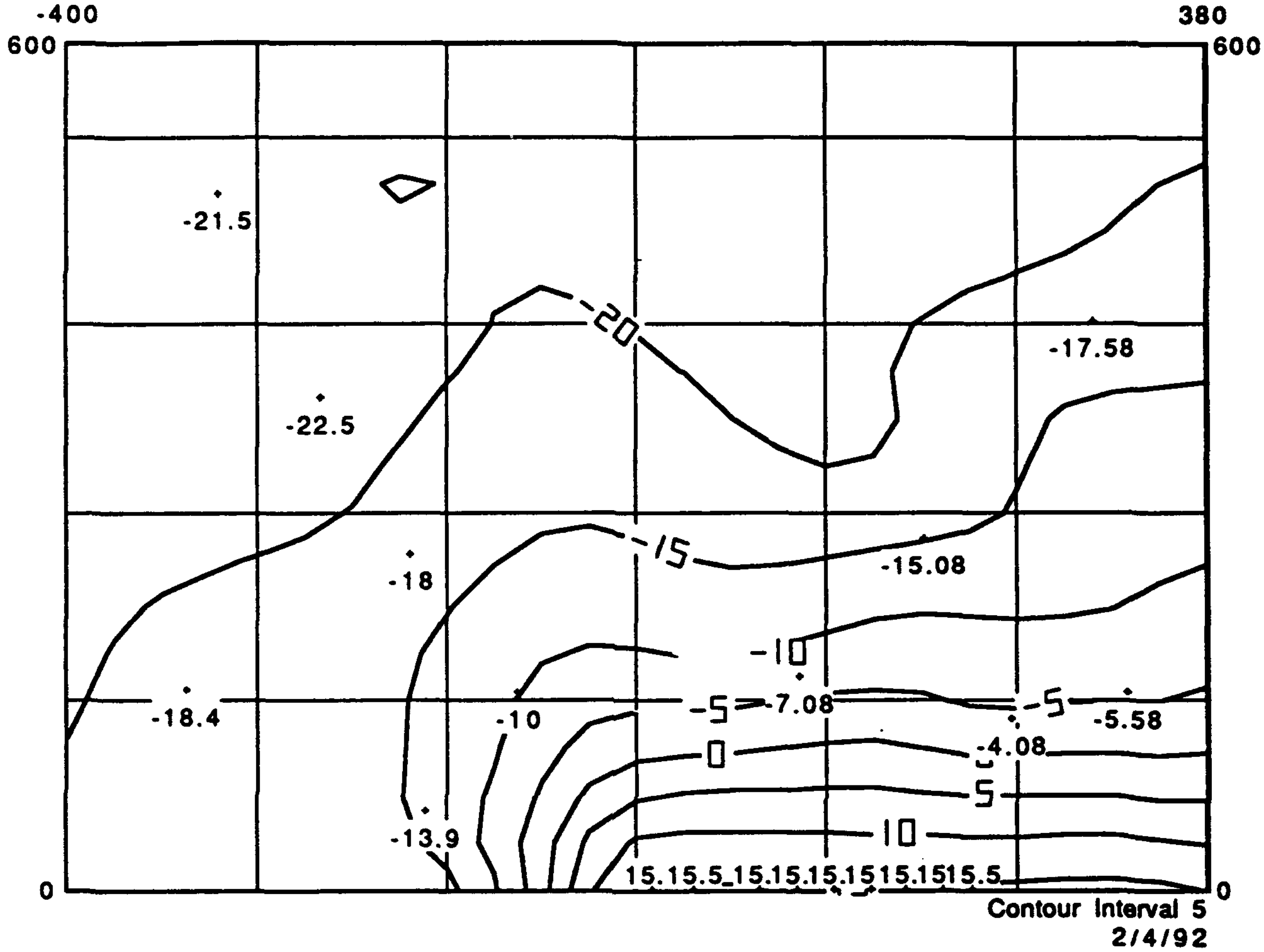

Shoal Survey: Bearing=340
10/21/75
5/16/79
11/01/91
12/12/91
El wrt MLLW (ft)
Dist. from BM 21+00 (ft)

FIGURE II-17



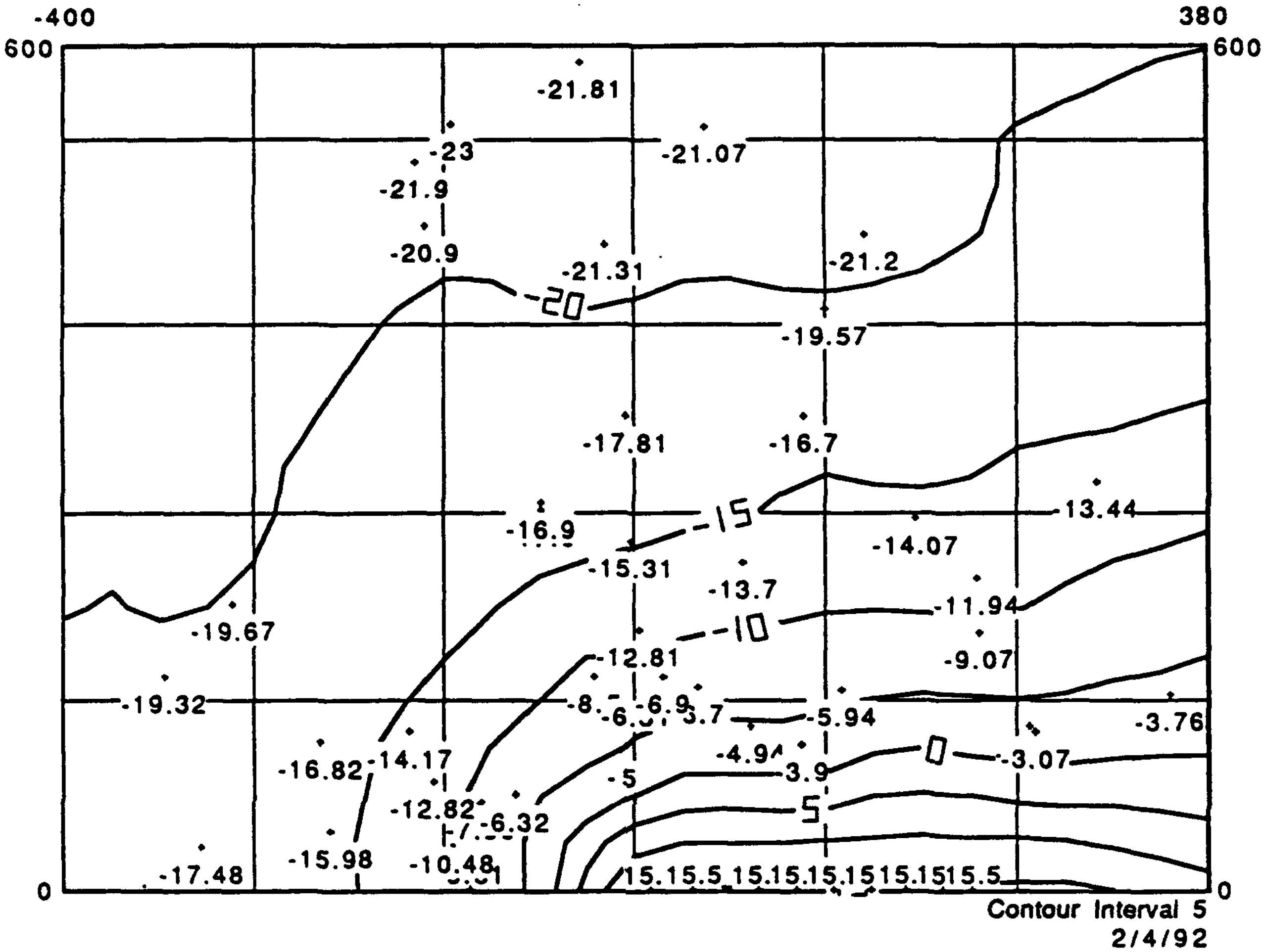
May 16-18 1979
West Jetty Tip Shoal
Elevations wrt MLLW

FIGURE II-18



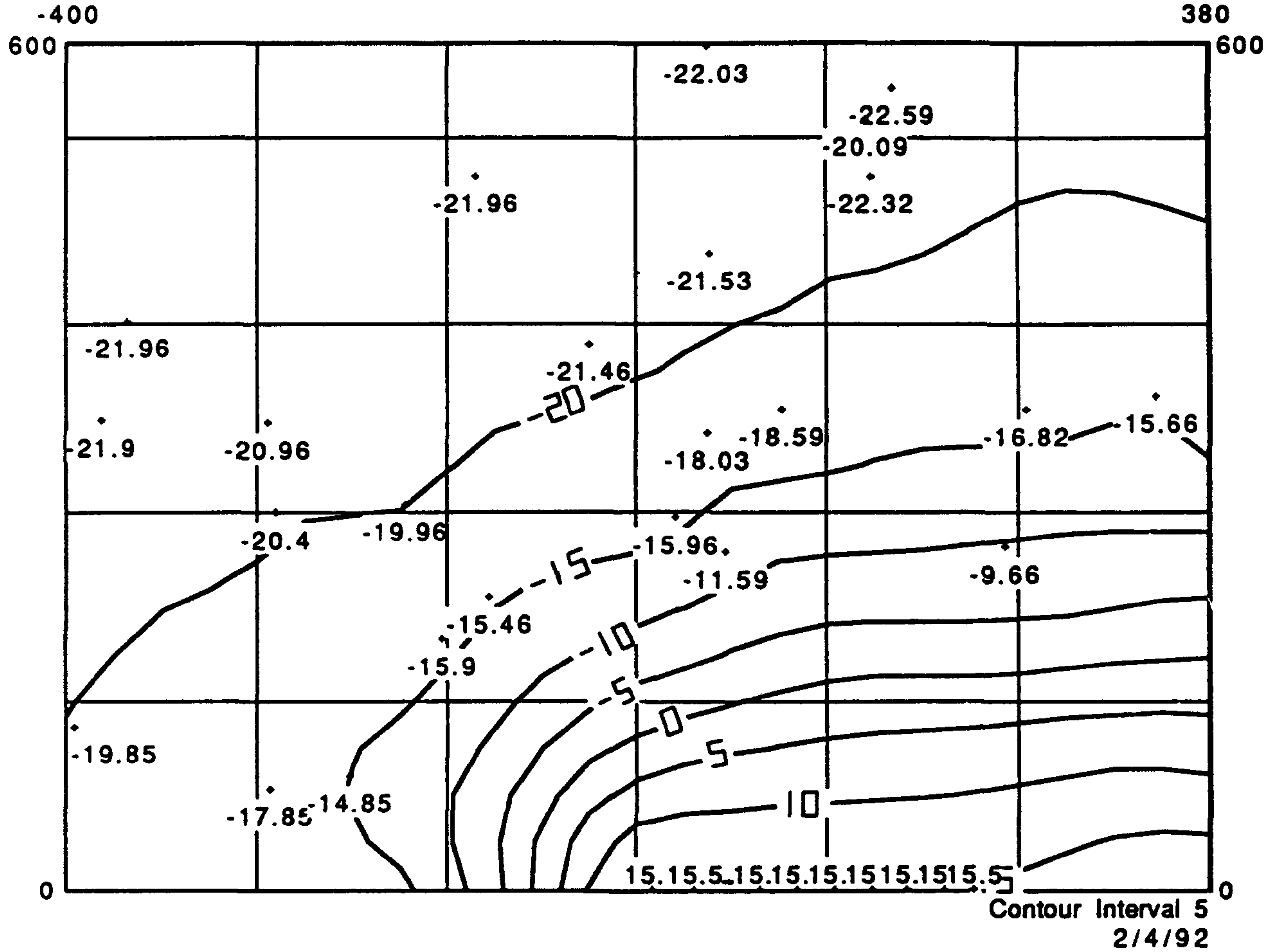
September 27, 1991
West Jetty Tip Shoal
Elevations are wrt MLLW

FIGURE II-19



November 1, 1991
West Jetty Tip Shoal
Elevations are wrt MLLW

FIGURE II-20



December 12, 1991

West Jetty Tip Shoal

Elevations are wrt MLLW

FIGURE II-21

Three Dimensional View

May 16-18 1979
West Jetty Tip Shoal
5 Z Axis Scale (normalized)
0 Perspective Setting
225° of Yaw
80° of Pitch
0° of Roll

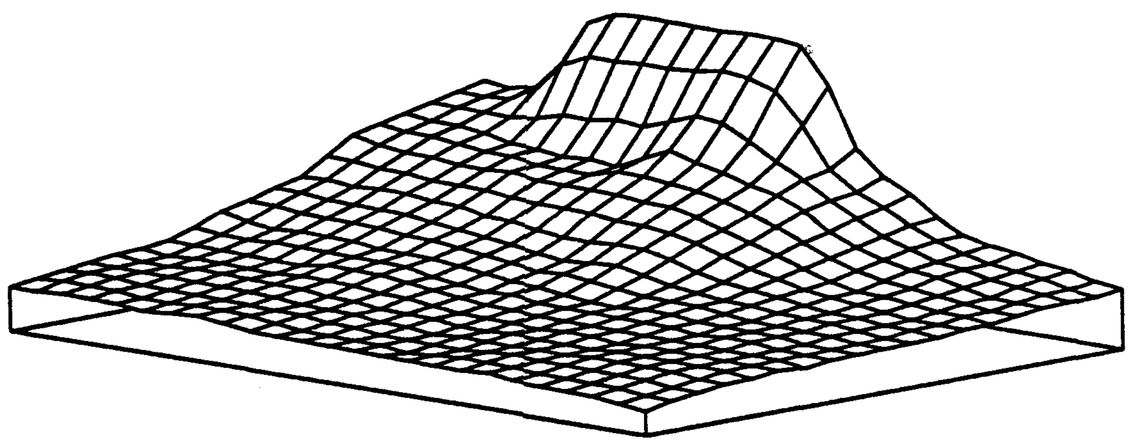


FIGURE II-22

Three Dimensional View

September 27, 1991
West Jetty Tip Shoal
5 Z Axis Scale (normalized)
0 Perspective Setting
225° of Yaw
80° of Pitch
0° of Roll

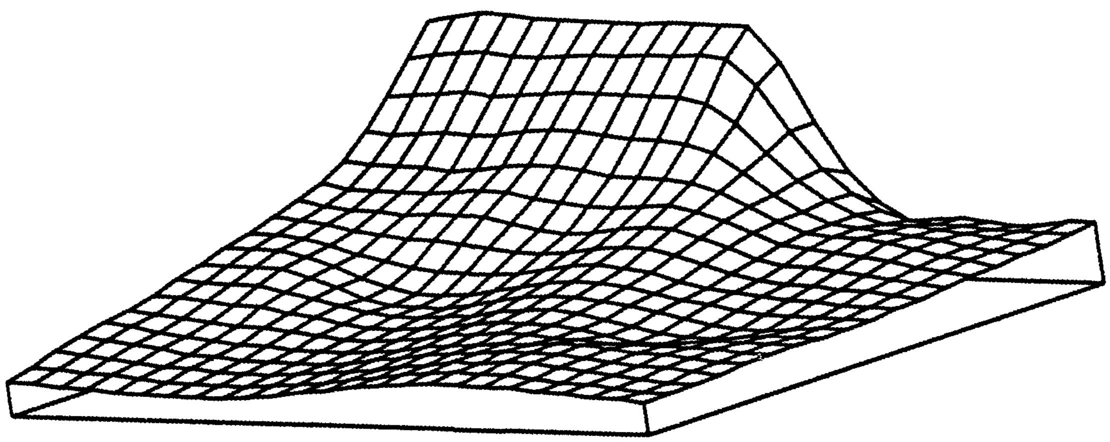


FIGURE II-23

Three Dimensional View

November 1, 1991
West Jetty Tip Shoal
5 Z Axis Scale (normalized)
0 Perspective Setting
225° of Yaw
80° of Pitch
0° of Roll

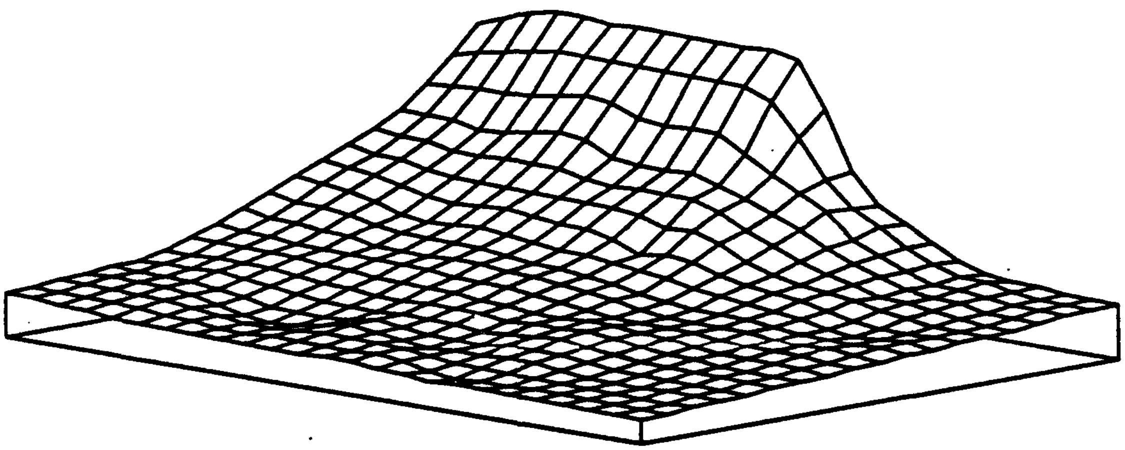


FIGURE II-24

Three Dimensional View

December 12, 1991
West Jetty Tip Shoal
5 Z Axis Scale (normalized)
0 Perspective Setting
225° of Yaw
80° of Pitch
0° of Roll

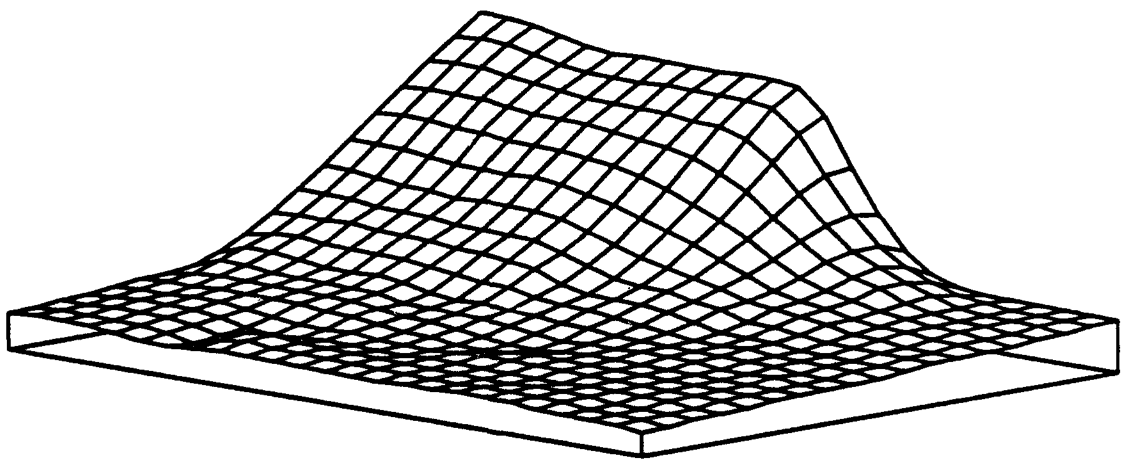


FIGURE II-25

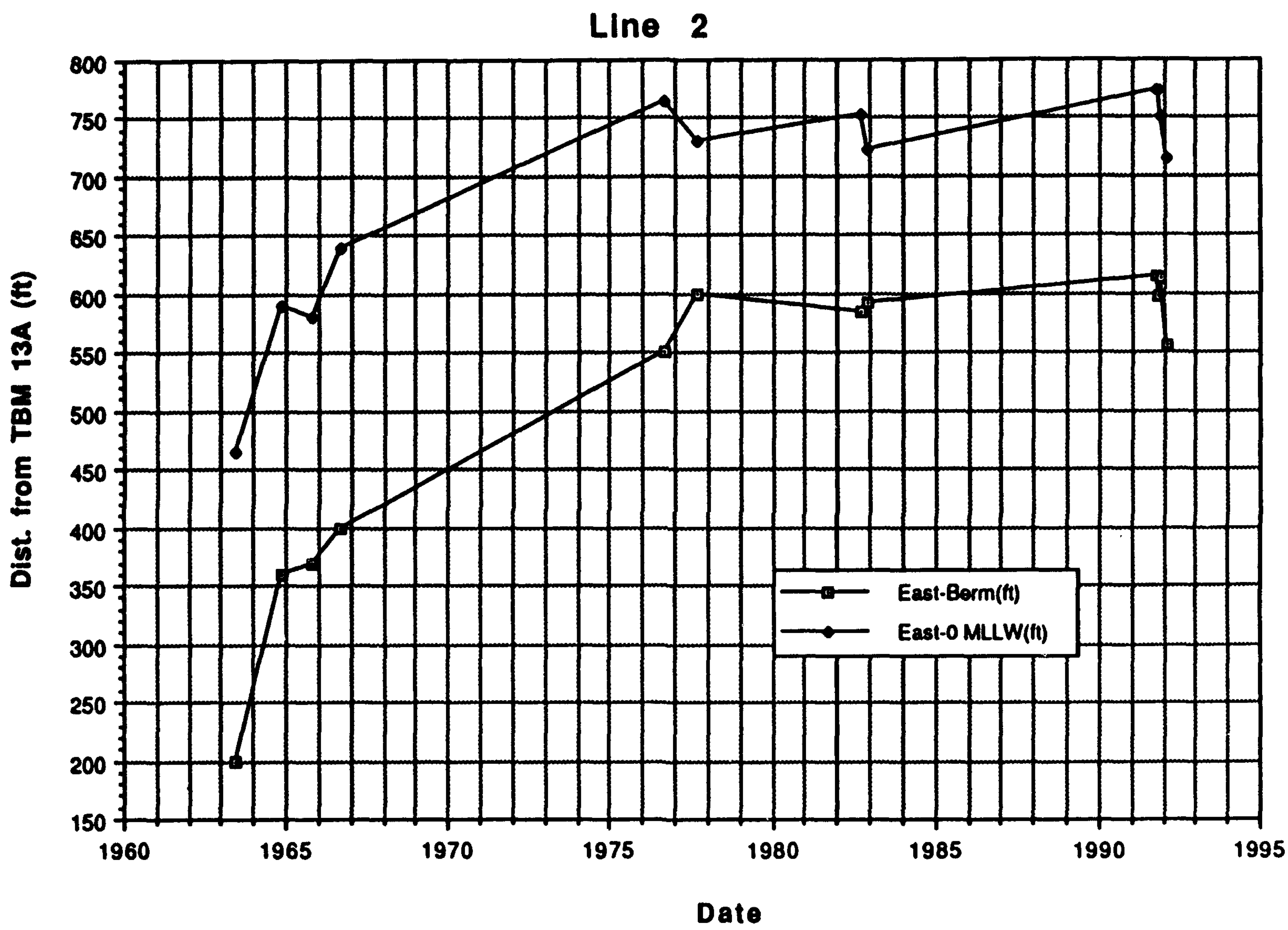


FIGURE II-26: HISTORIC LOCATIONS OF BEACH FACE, LINE 2

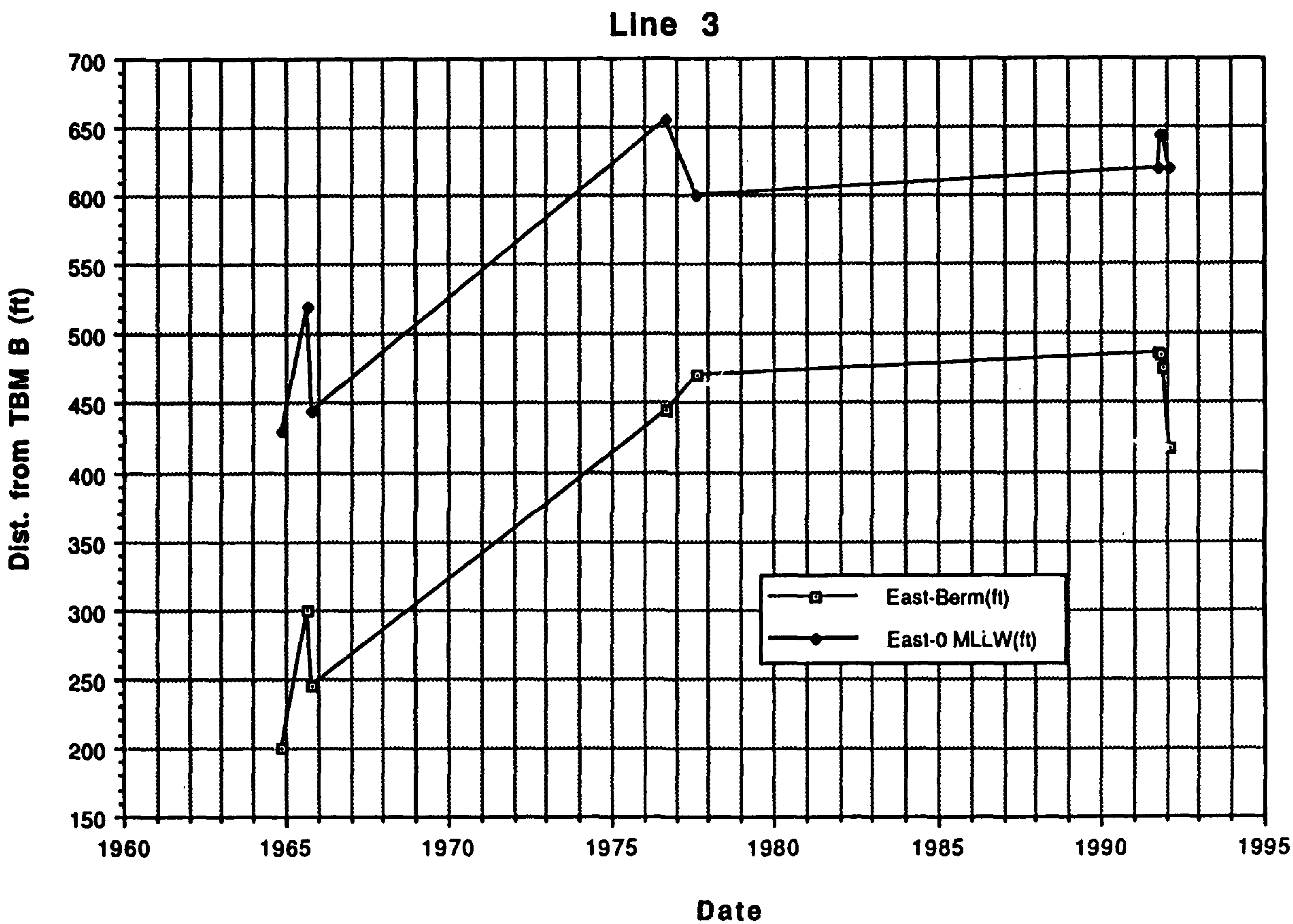


FIGURE II-27: HISTORIC LOCATIONS OF BEACH FACE, LINE 3

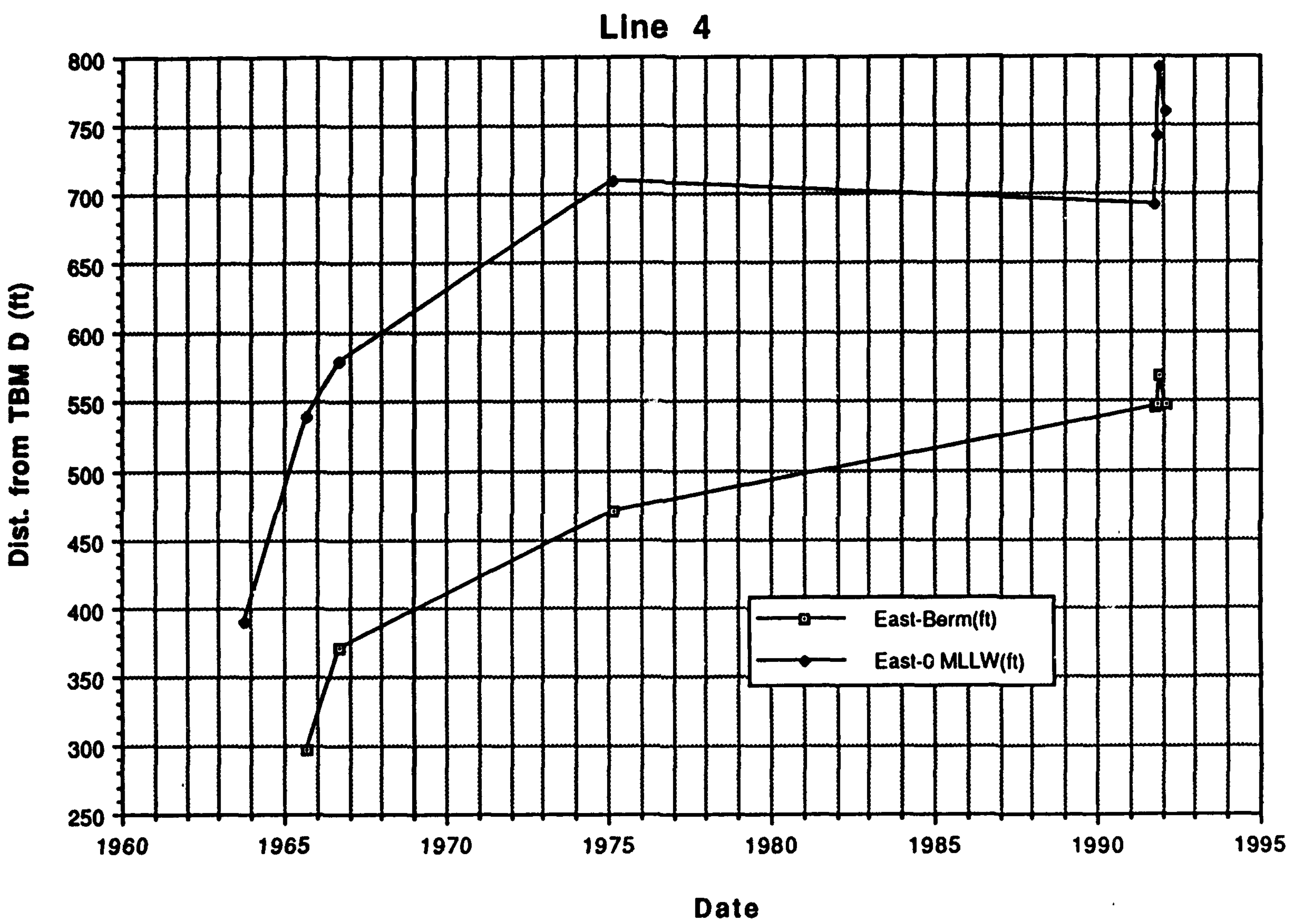


FIGURE II-28: HISTORIC LOCATION OF BEACH FACE, LINE 4

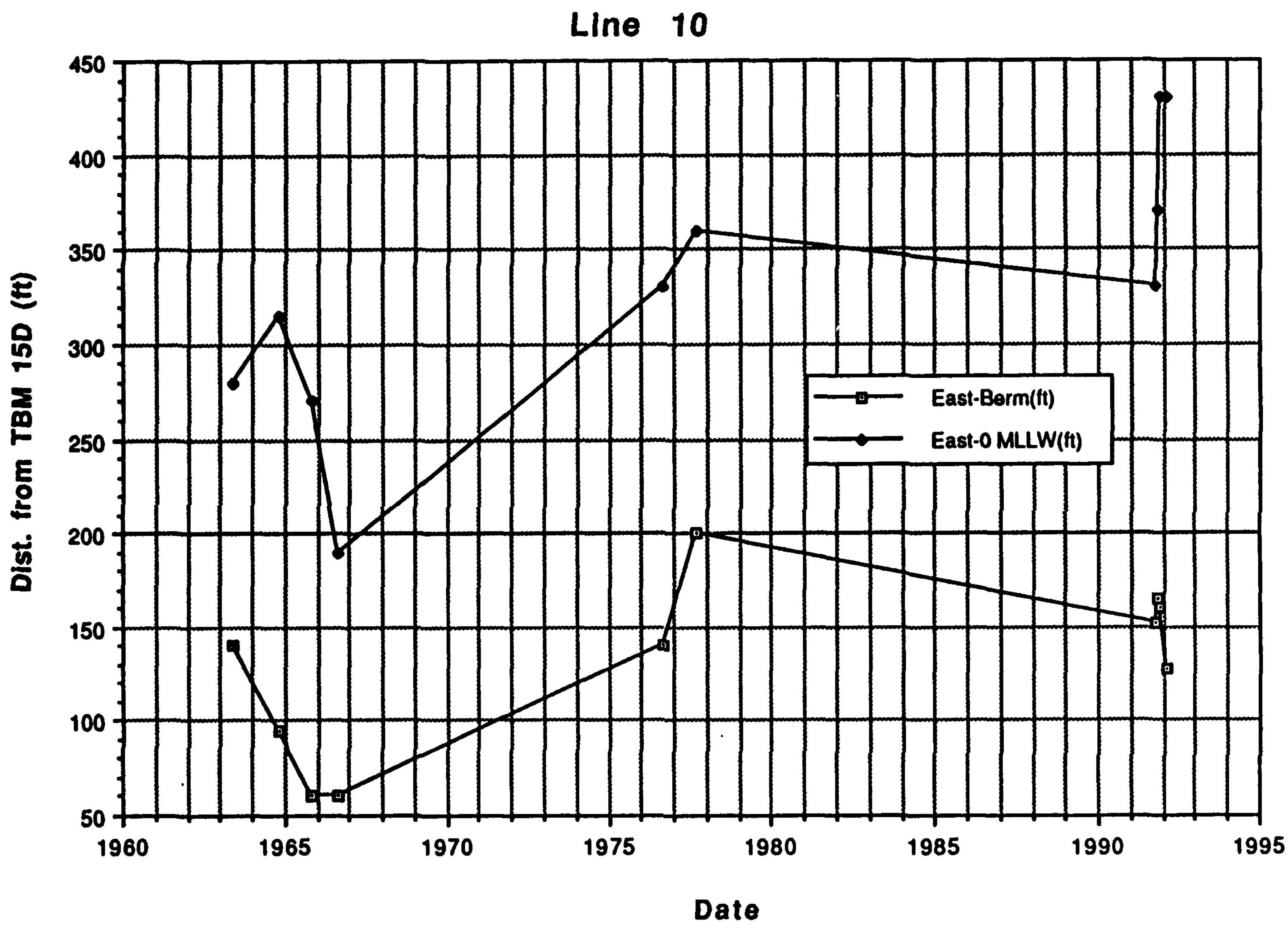
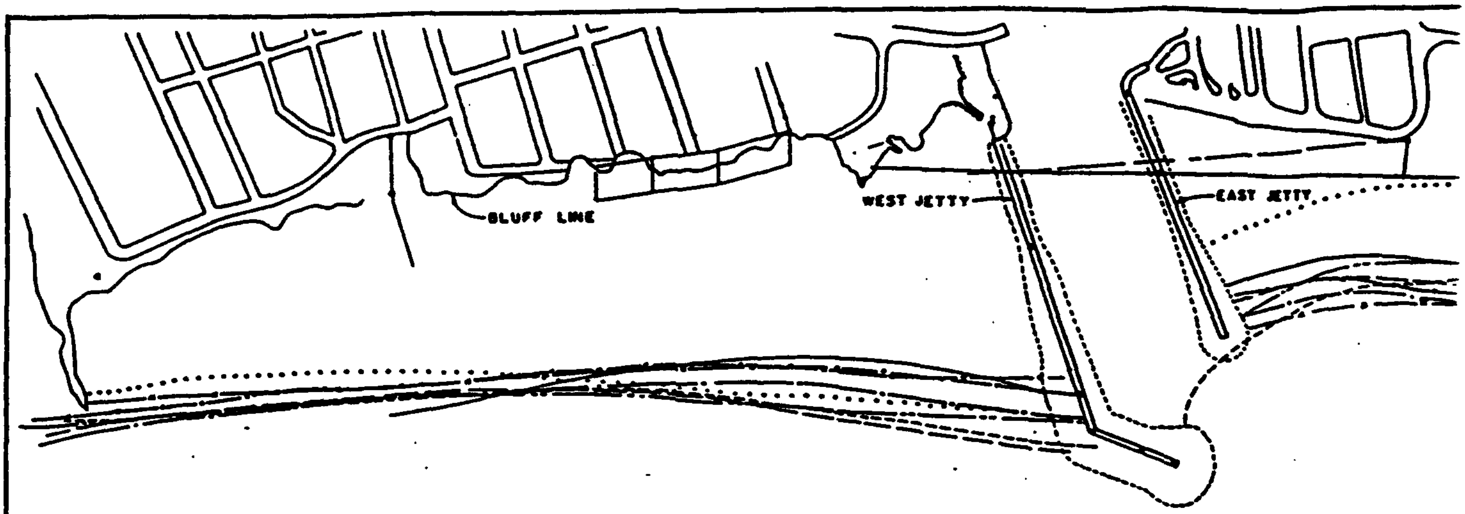
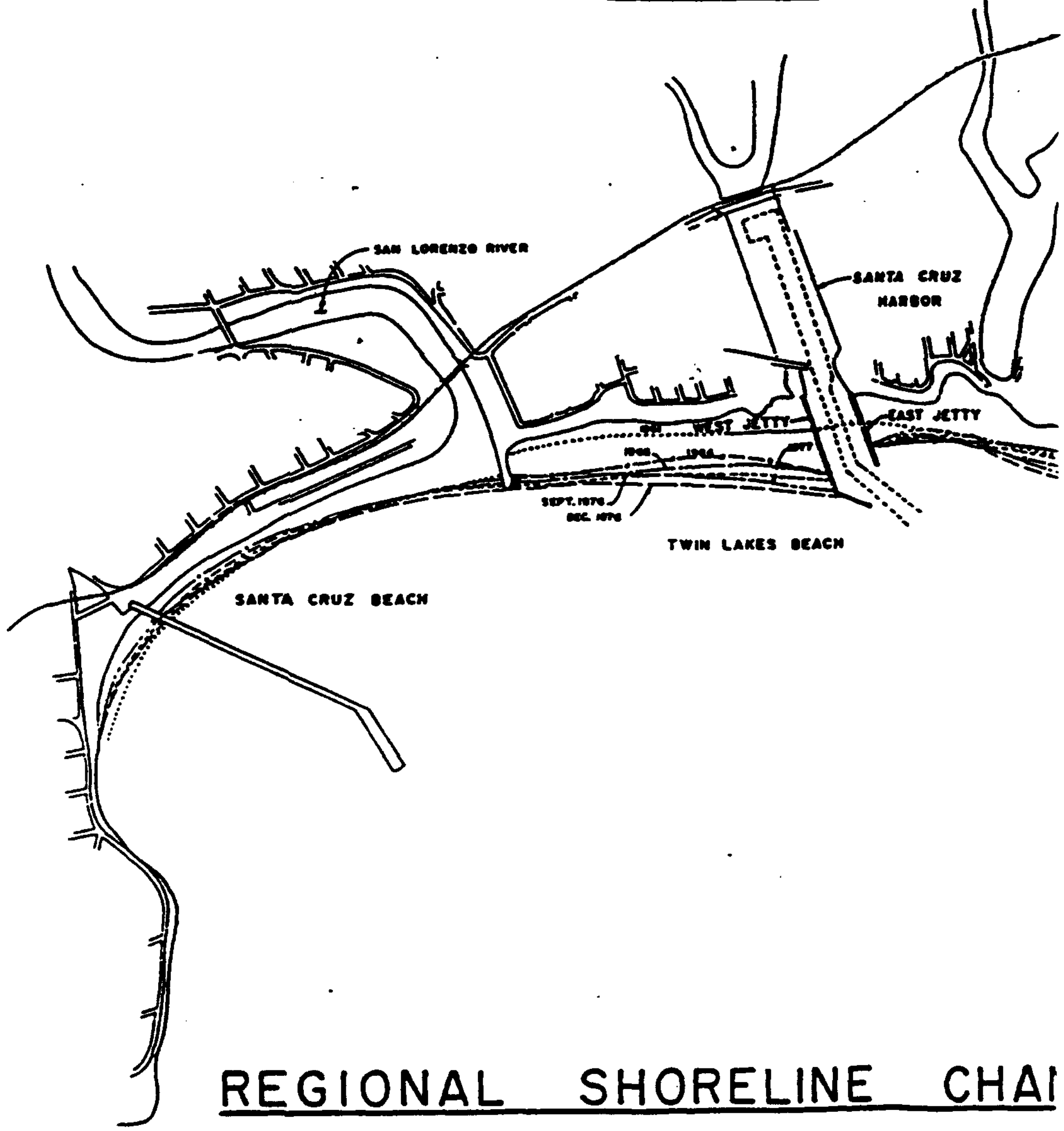


FIGURE II-29: HISTORIC LOCATIONS OF BEACH FACE, LINE 10



SEASONAL SHORELINE CHAN

SCALE IN FEET

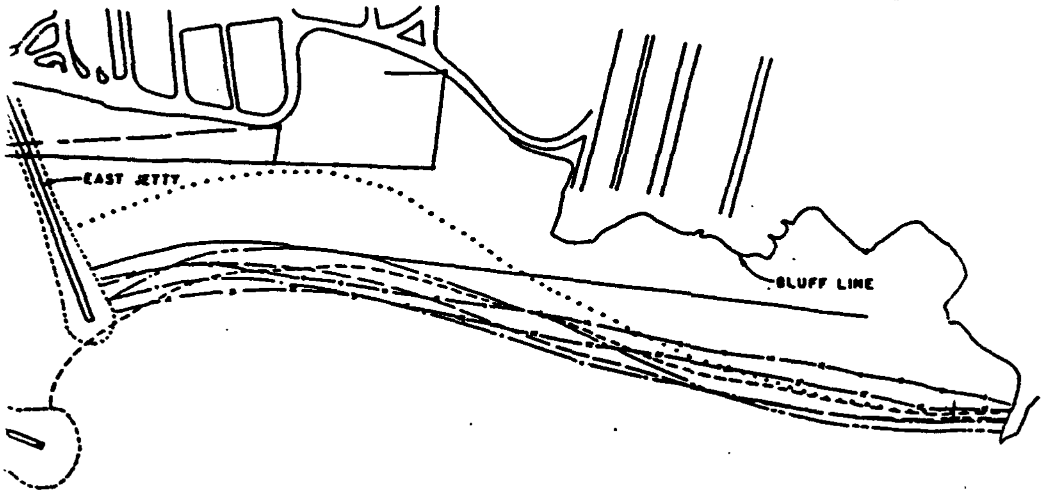


REGIONAL SHORELINE CHAI

SCALE IN FEET

FIGURE III-1: HISTORIC SHORELINES; 1961 TO 1978 (SOURCE: MO

A

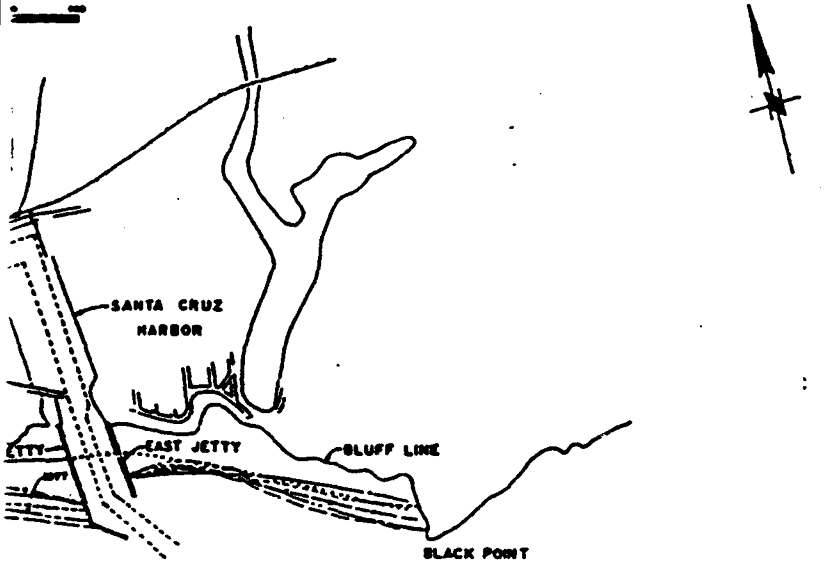


L E G E N D

SEPTEMBER	1976	
NOVEMBER	1976	
DECEMBER	1976	
JANUARY	1977	
FEBRUARY	1977	
MARCH	1977	
AUGUST	1977	
FEBRUARY	1978	

LINE CHANGES

ET



L E G E N D

DECEMBER	1961*	
OCTOBER	1964	
AUGUST	1966	
SEPTEMBER	1976	
DECEMBER	1976	
APRIL	1977	

N O T E S

1. ELEVATIONS AND SOUNDINGS ARE BASED ON THE DATUM OF MEAN LOWER LOW WATER.

*2. SHORELINE DRAWN FROM AERIAL PHOTOGRAPHS.

:LINE CHANGES

:ET

978 (SOURCE: MOFFATT & NICHOL, ENGINEERS, 1978)

SANTA CRUZ HARBOR, CALIFORNIA
SHOALING STUDY

SEASONAL AND REGIONAL SHORELINE CHANGES

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO

Prepared & Submitted By : Moffatt & Nichol, Engineers Long Beach, California	To Accompany Shoaling Study Report Dated : June 1978

B

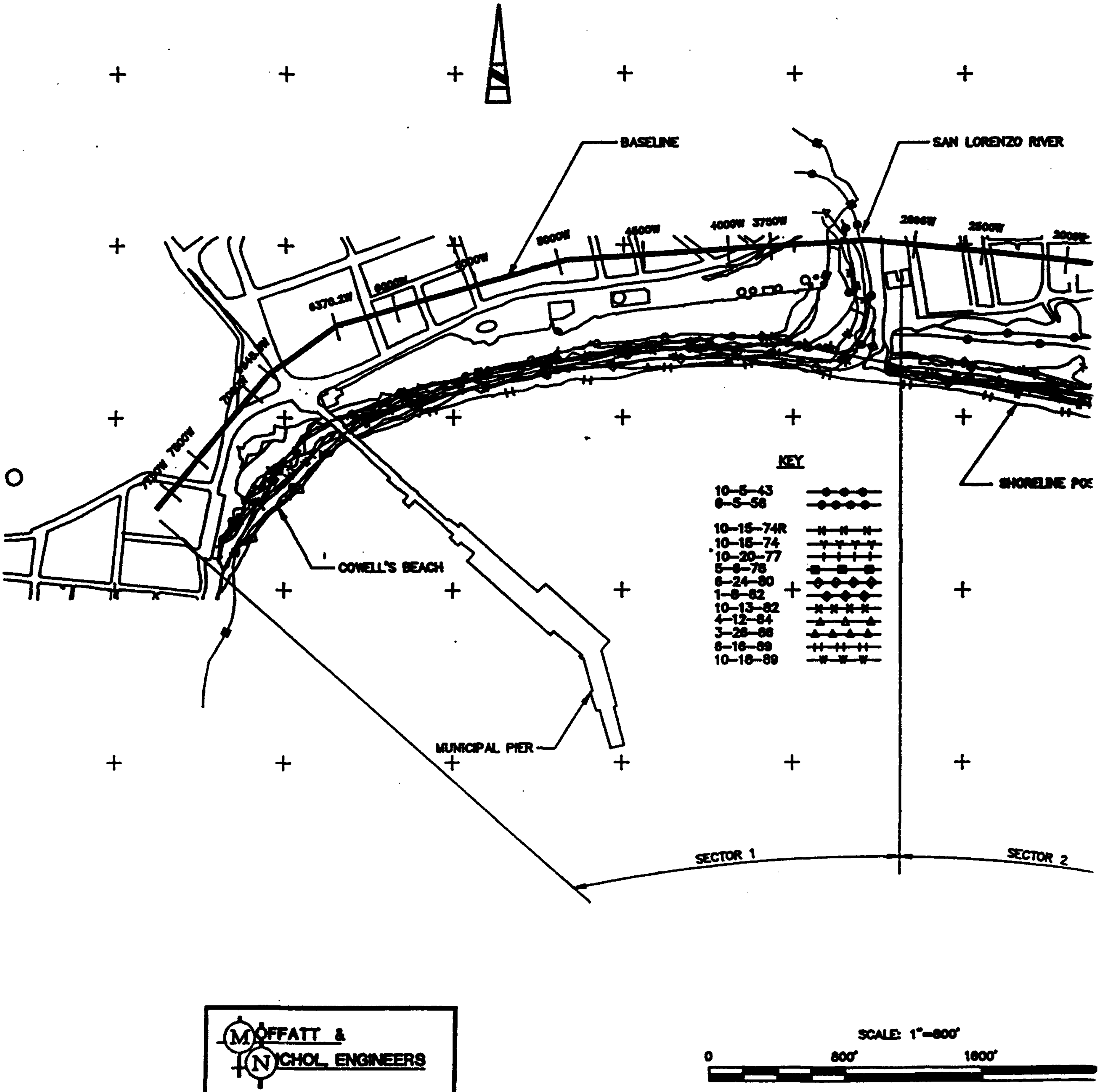
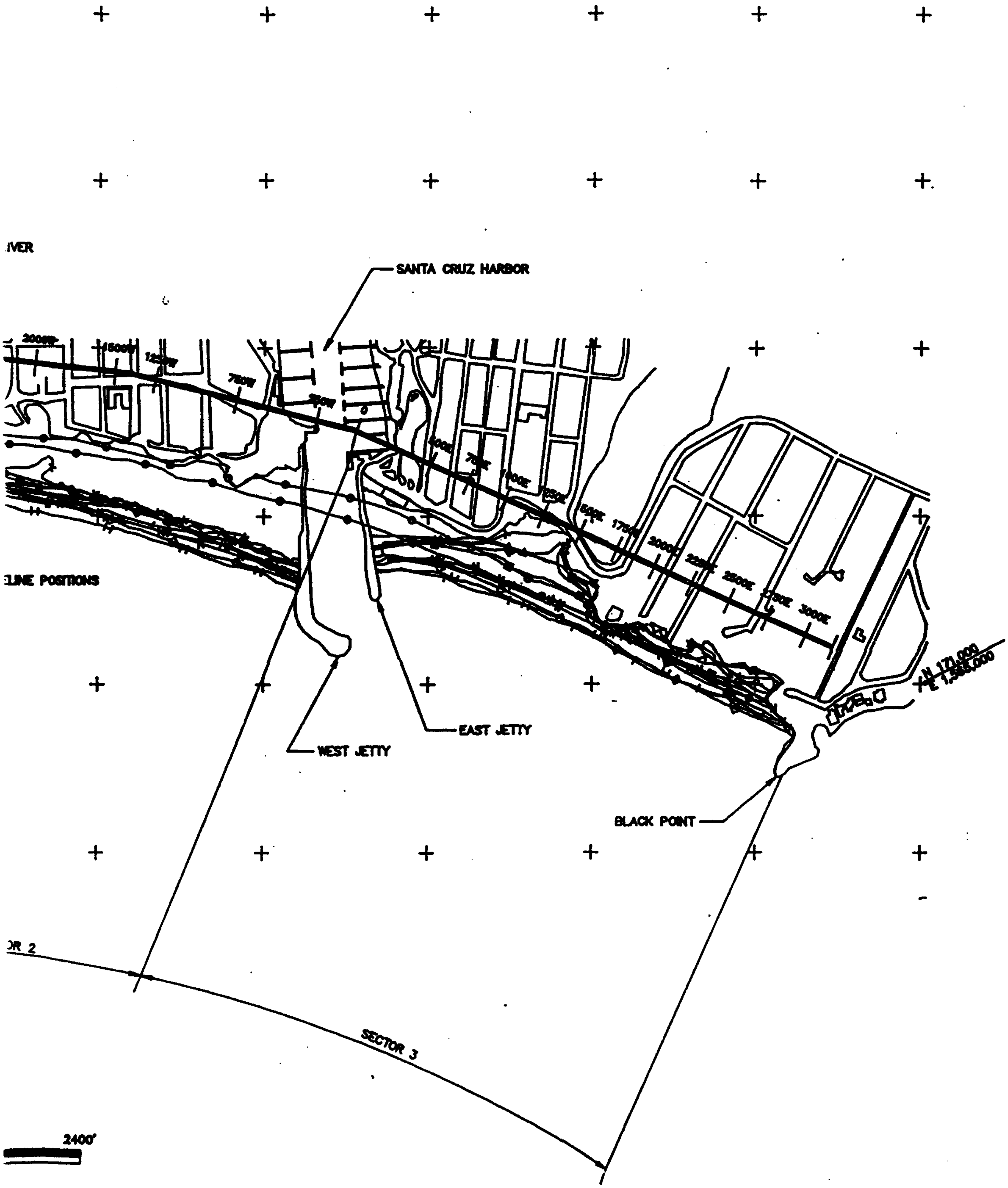


FIGURE III-2: HISTORIC SHORELINES COWELL'S BEACH

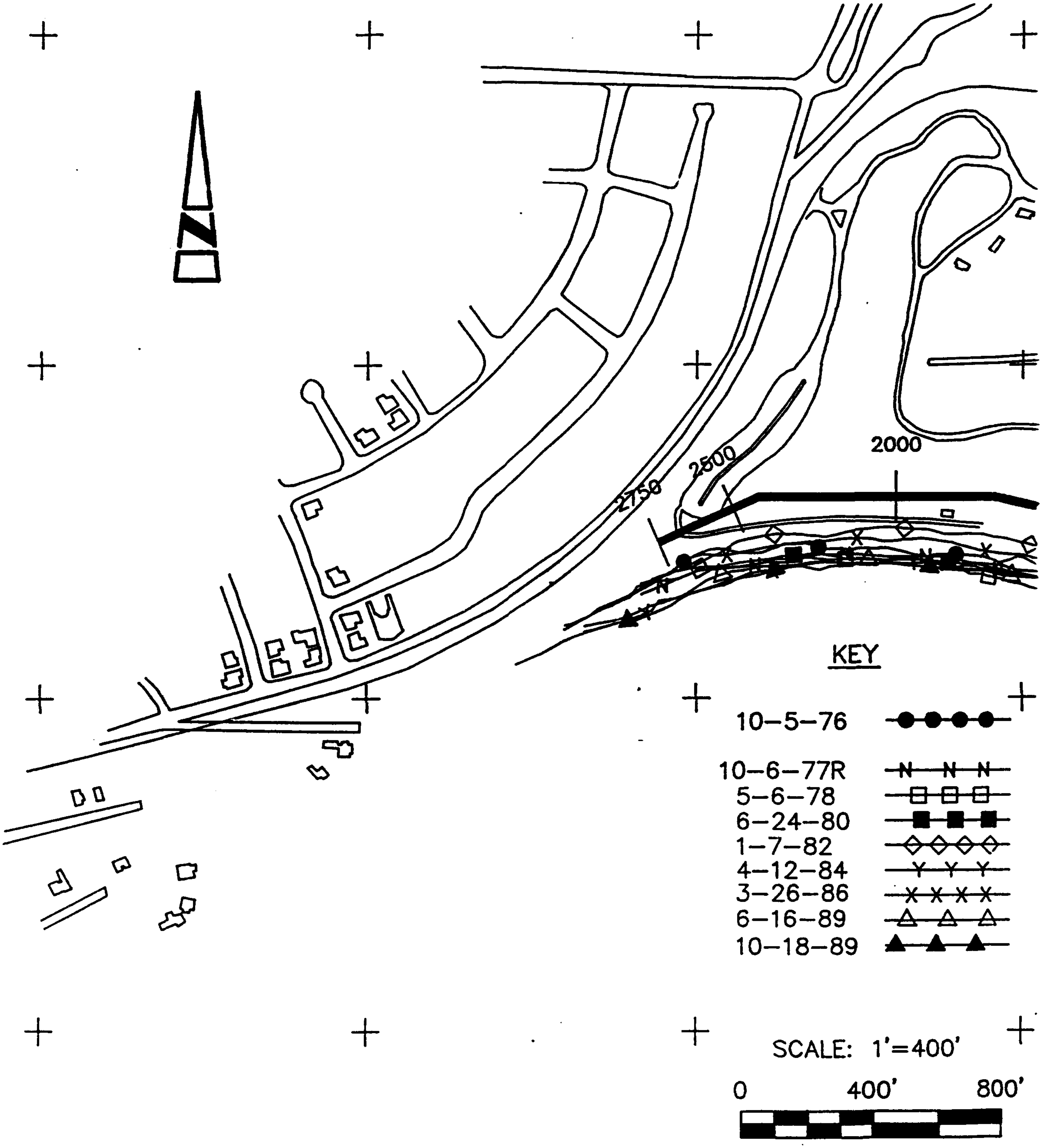
A



ES; 1943,1956, AND 1974 TO 1989.

H TO BLACK POINT.

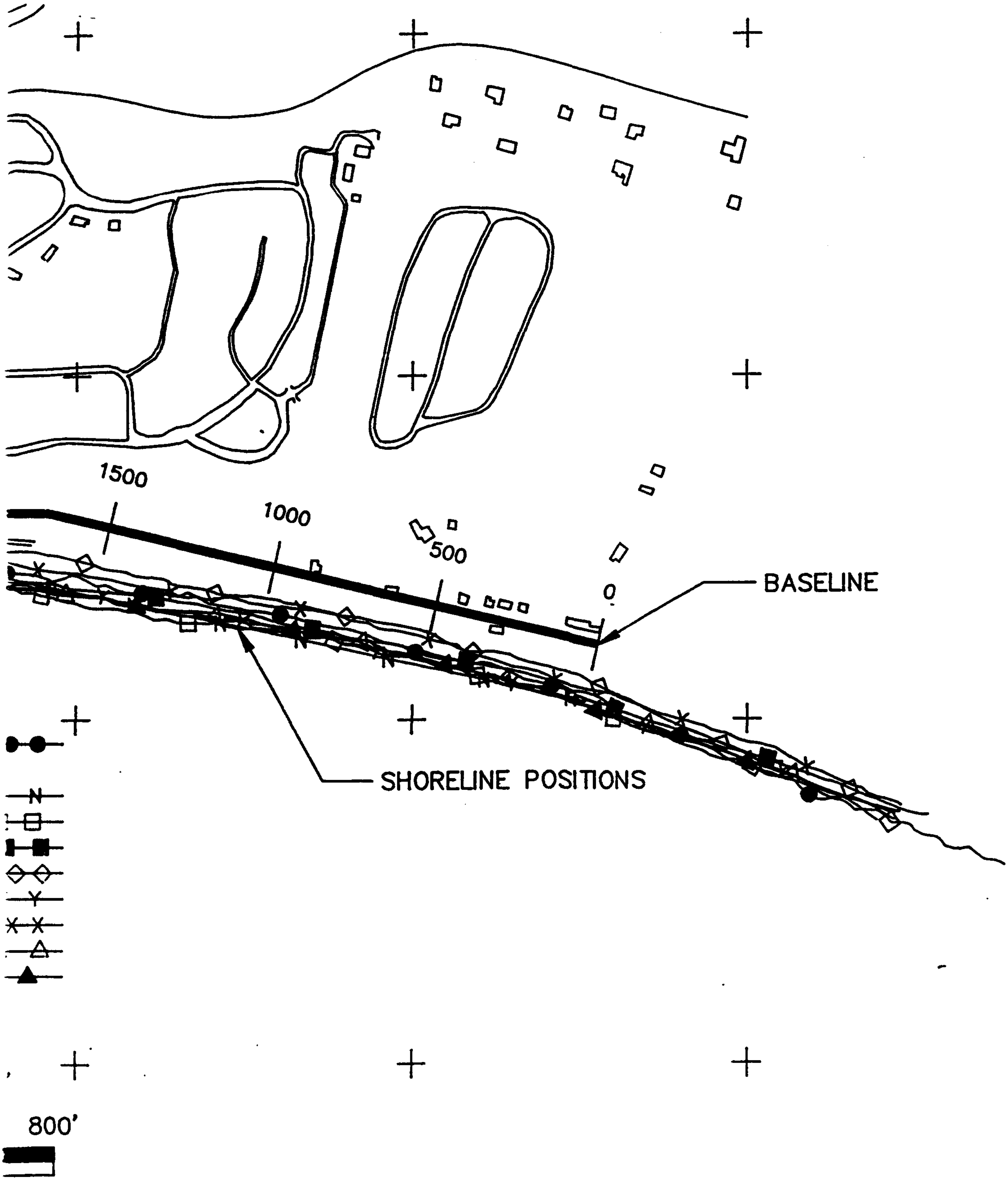
B



MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

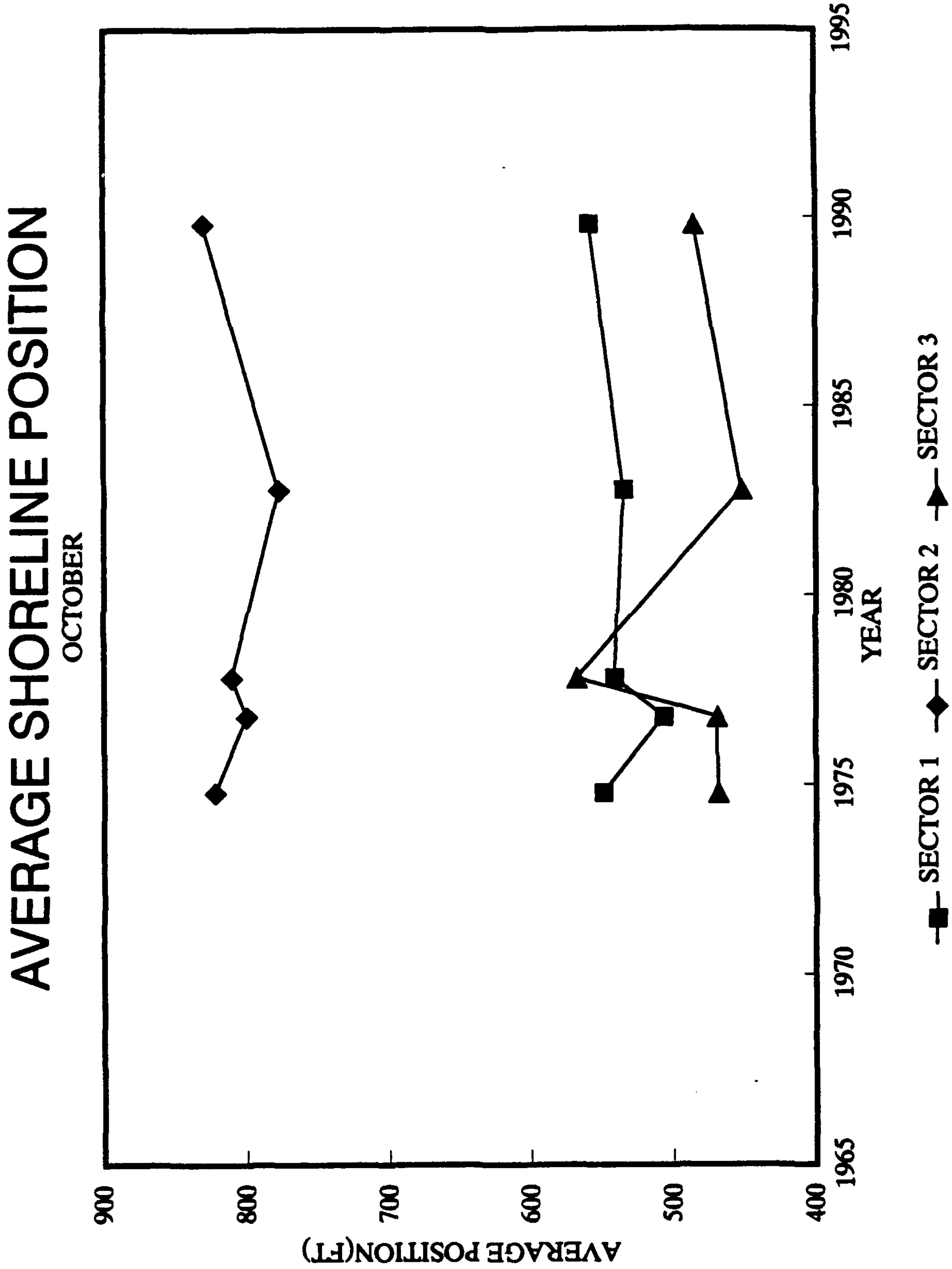
FIGURE III-3; HISTORIC SHOREL

NEW BRIGHTON BE



RELINES; 1976 TO 1989.

BEACH



AVERAGE SHORELINE POSITION
OCTOBER
AVERAGE POSITION(FT)
900
800
700
600
500
400
1965
1970
1975
1980
1985
1990
1995
YEAR
SECTOR 1
SECTOR 2
SECTOR 3

FIGURE III-5

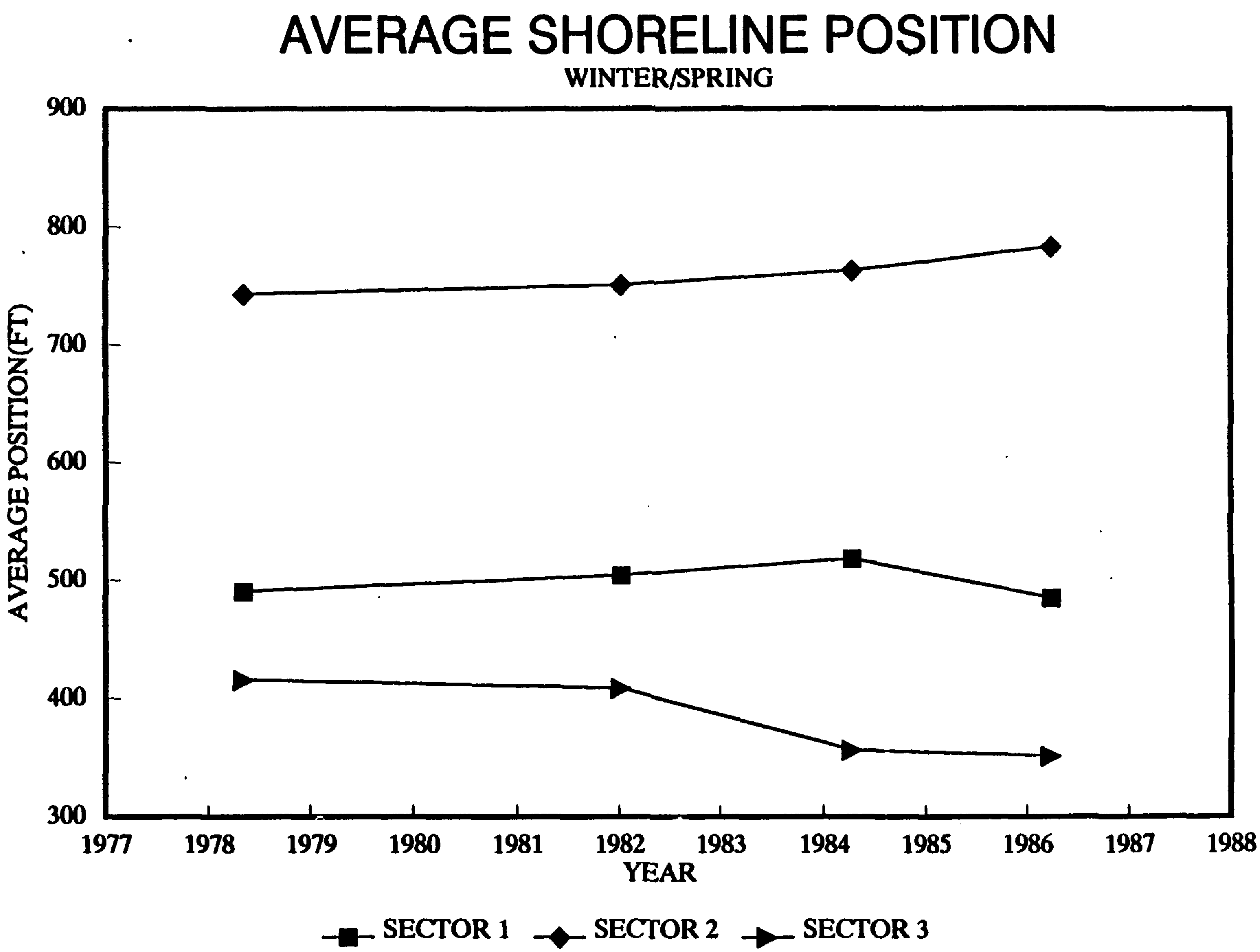

AVERAGE SHORELINE POSITION
WINTER/SPRING
900
800
700
600
500
400
300
AVERAGE POSITION(FT)
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
YEAR
SECTOR 1
SECTOR 2
SECTOR 3

FIGURE III-6

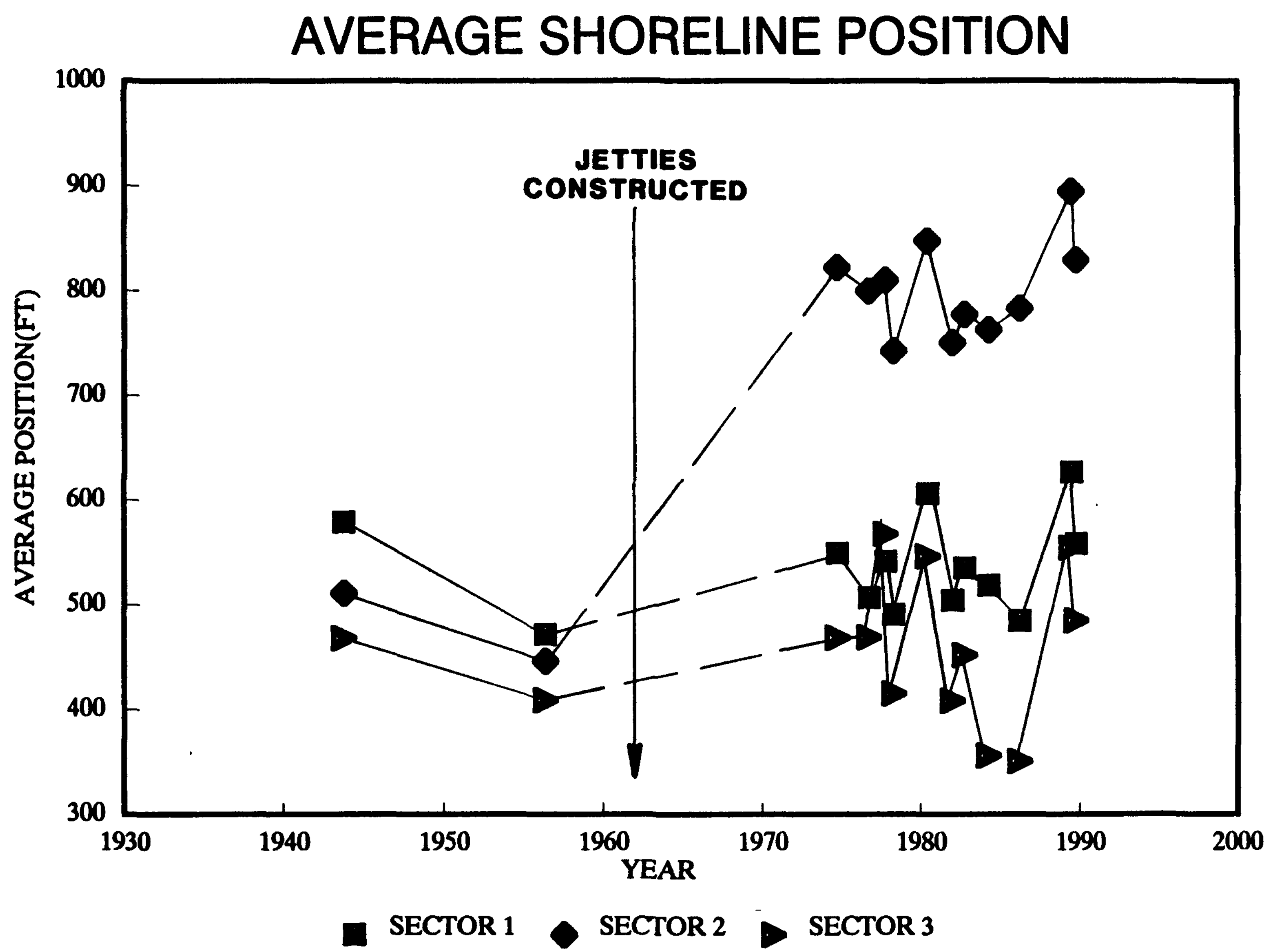

AVERAGE SHORELINE POSITION
JETTIES CONSTRUCTED
AVERAGE POSITION(FT)
1000
900
800
700
600
500
400
300
1930
1940
1950
1960
1970
1980
1990
2000
YEAR
SECTOR 1
SECTOR 2
SECTOR 3

FIGURE III-7

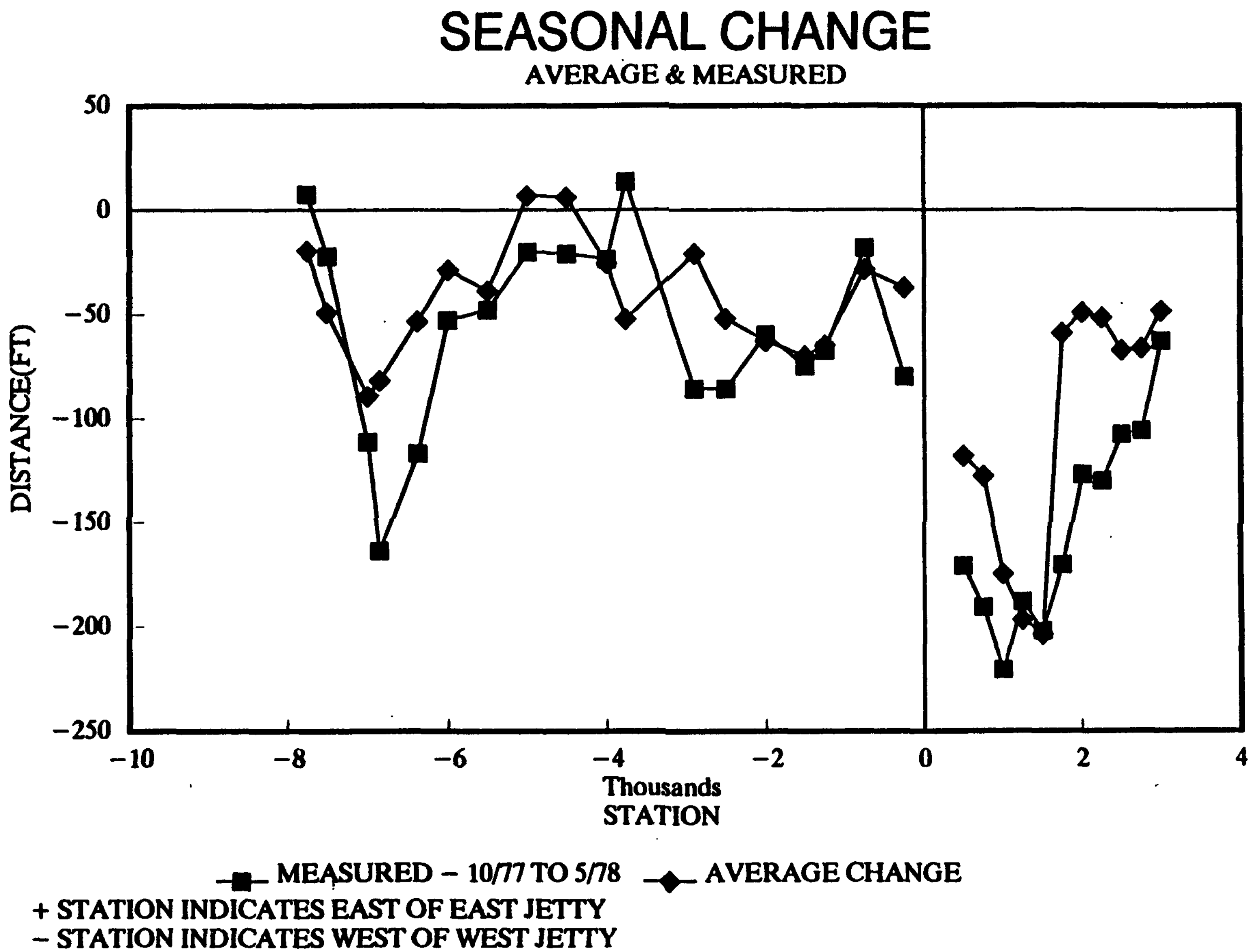
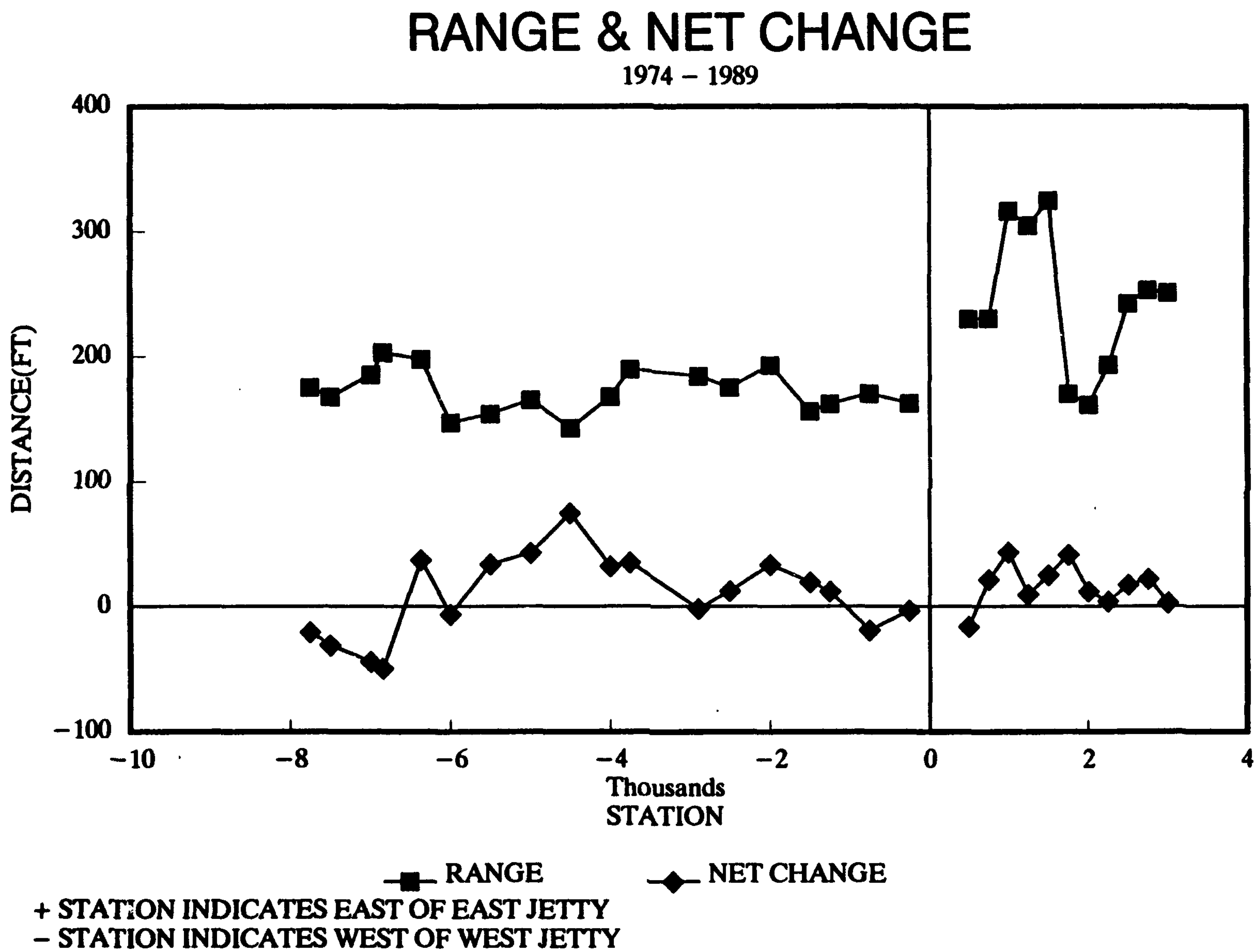
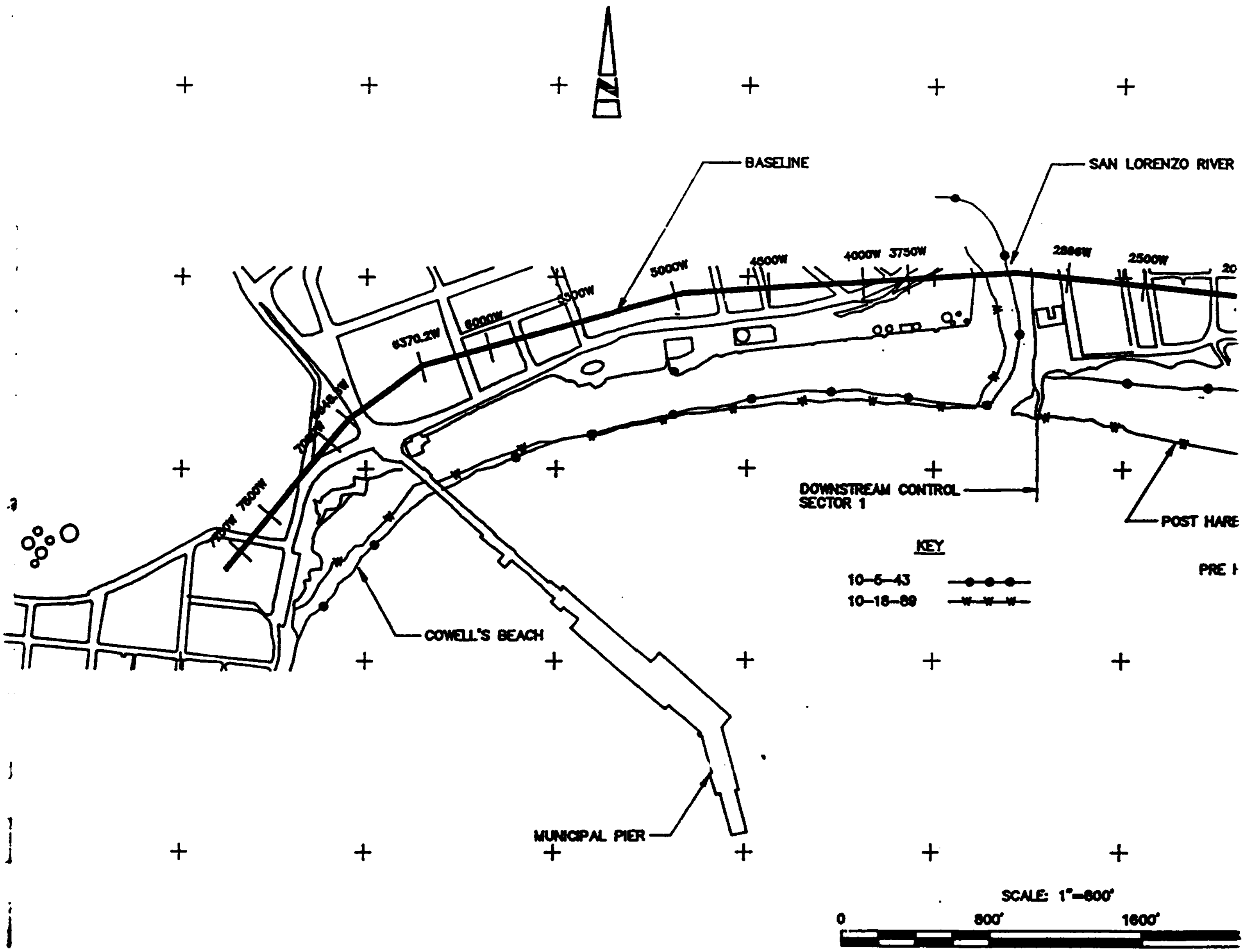

SEASONAL CHANGE
AVERAGE & MEASURED
DISTANCE(FT)
50
0
−50
−100
−150
−200
−250
−10
−8
−6
−4
−2
0
2
4
Thousands
STATION
MEASURED − 10/77 TO 5/78
AVERAGE CHANGE
+ STATION INDICATES EAST OF EAST JETTY
− STATION INDICATES WEST OF WEST JETTY

FIGURE III-8



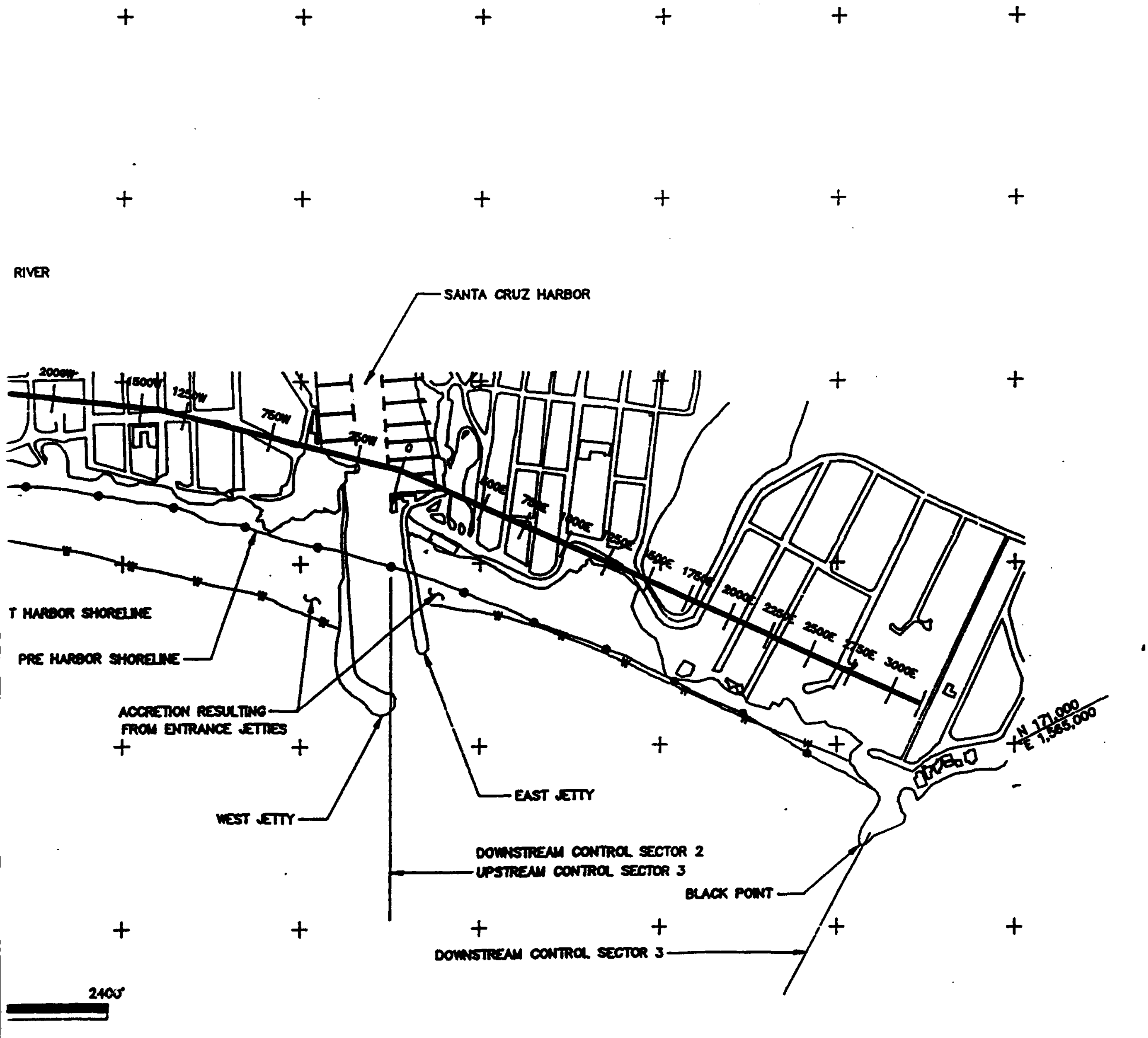
RANGE & NET CHANGE
1974 – 1989
DISTANCE(FT)
400
300
200
100
0
–100
–10
–8
–6
–4
–2
0
2
4
Thousands
STATION
RANGE
NET CHANGE
+ STATION INDICATES EAST OF EAST JETTY
– STATION INDICATES WEST OF WEST JETTY

FIGURE III-9



MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

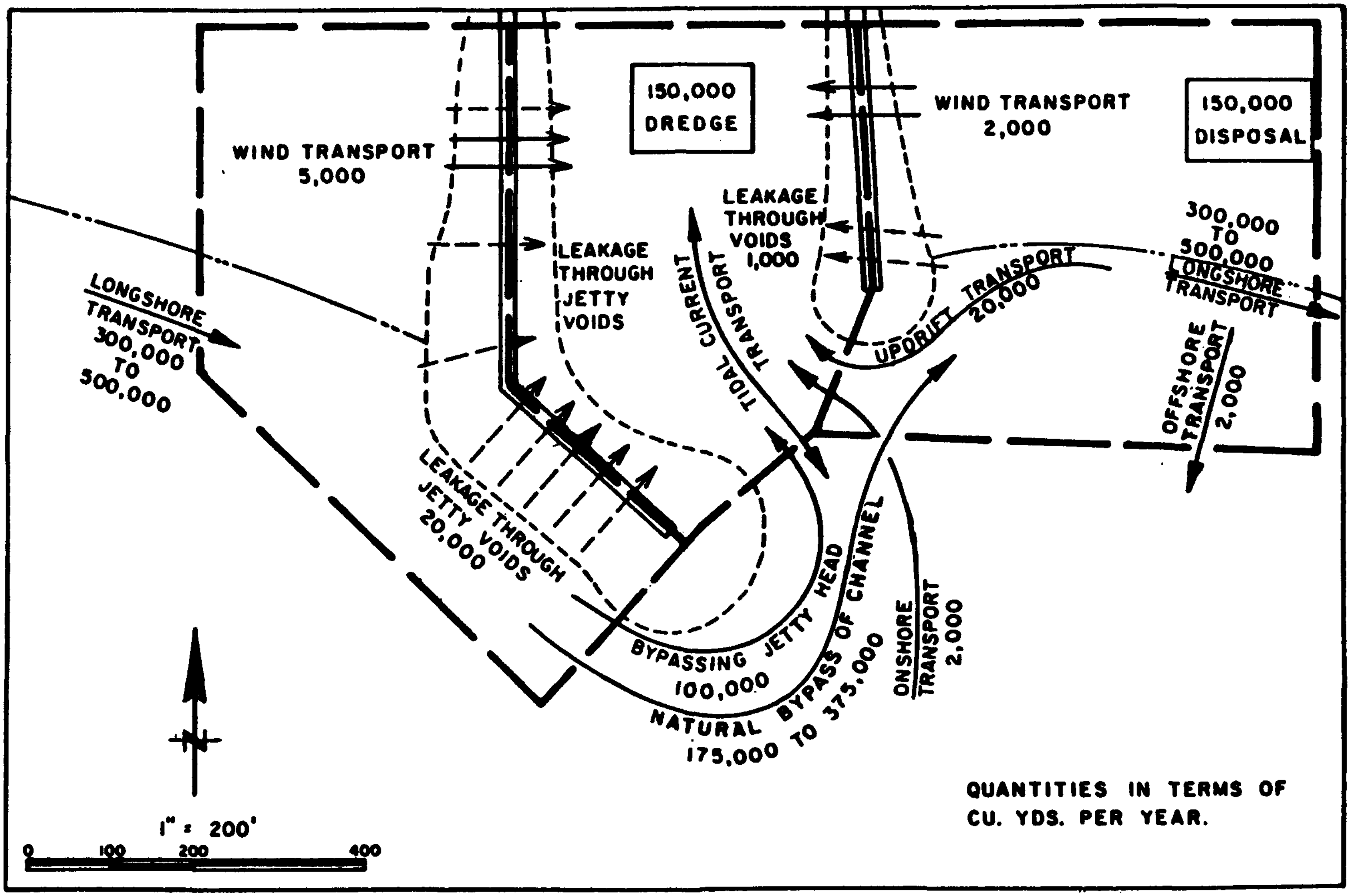
FIGURE III-10 OCTOBER SH
AND AFTER HARBOR C



SHORELINES BEFORE CONSTRUCTION

β

PREVIOUS SEDIMENT BUDGET
SANTA CRUZ HARBOR ENTRANCE
(SOURCE: MOFFATT & NICHOL, ENGINEERS, 1978)



MOFFATT &NICHOL, 1978

FIGURE IV-1

SEDIMENT BUDGET
SANTA CRUZ HARBOR ENTRANCE

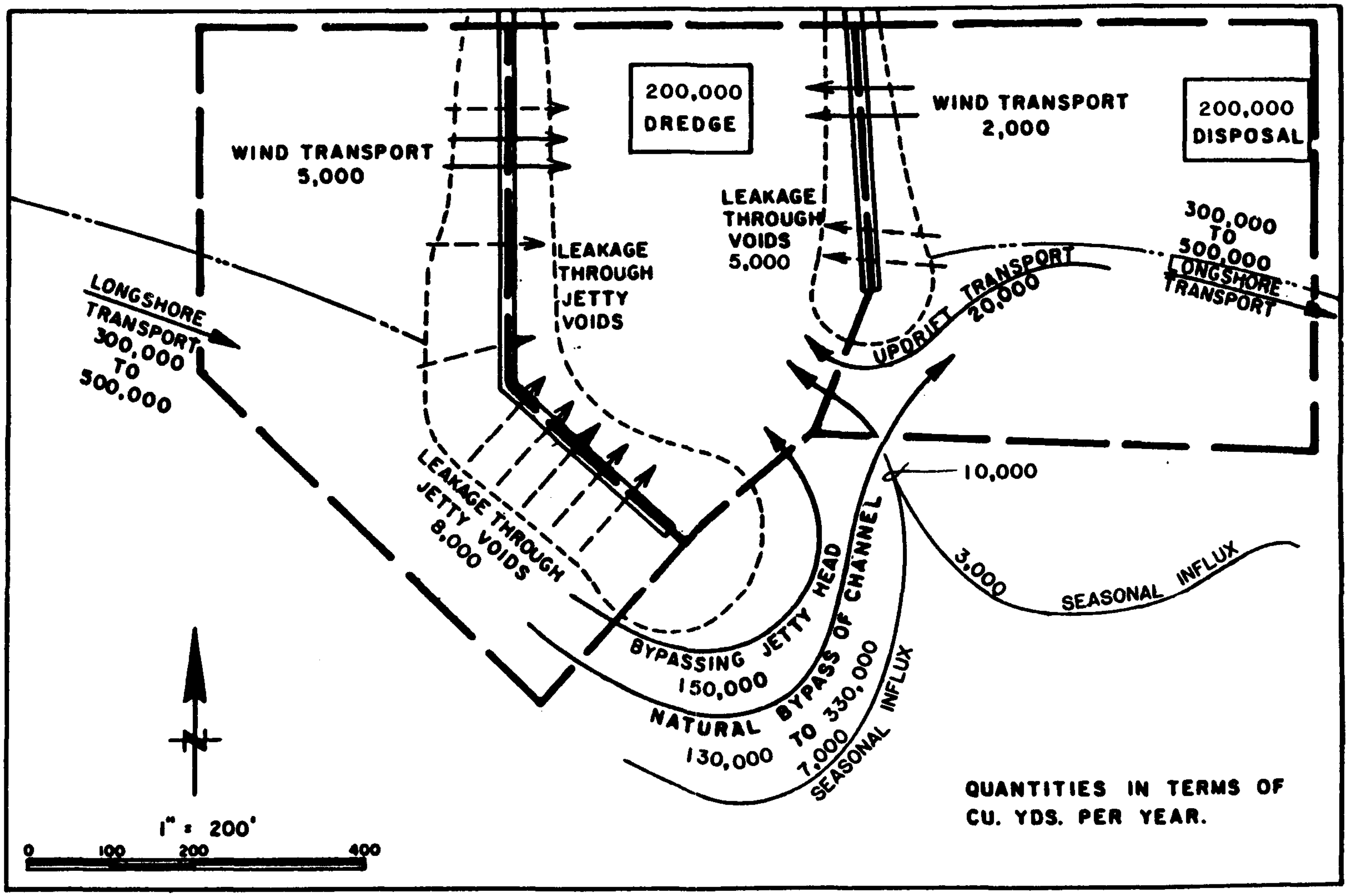
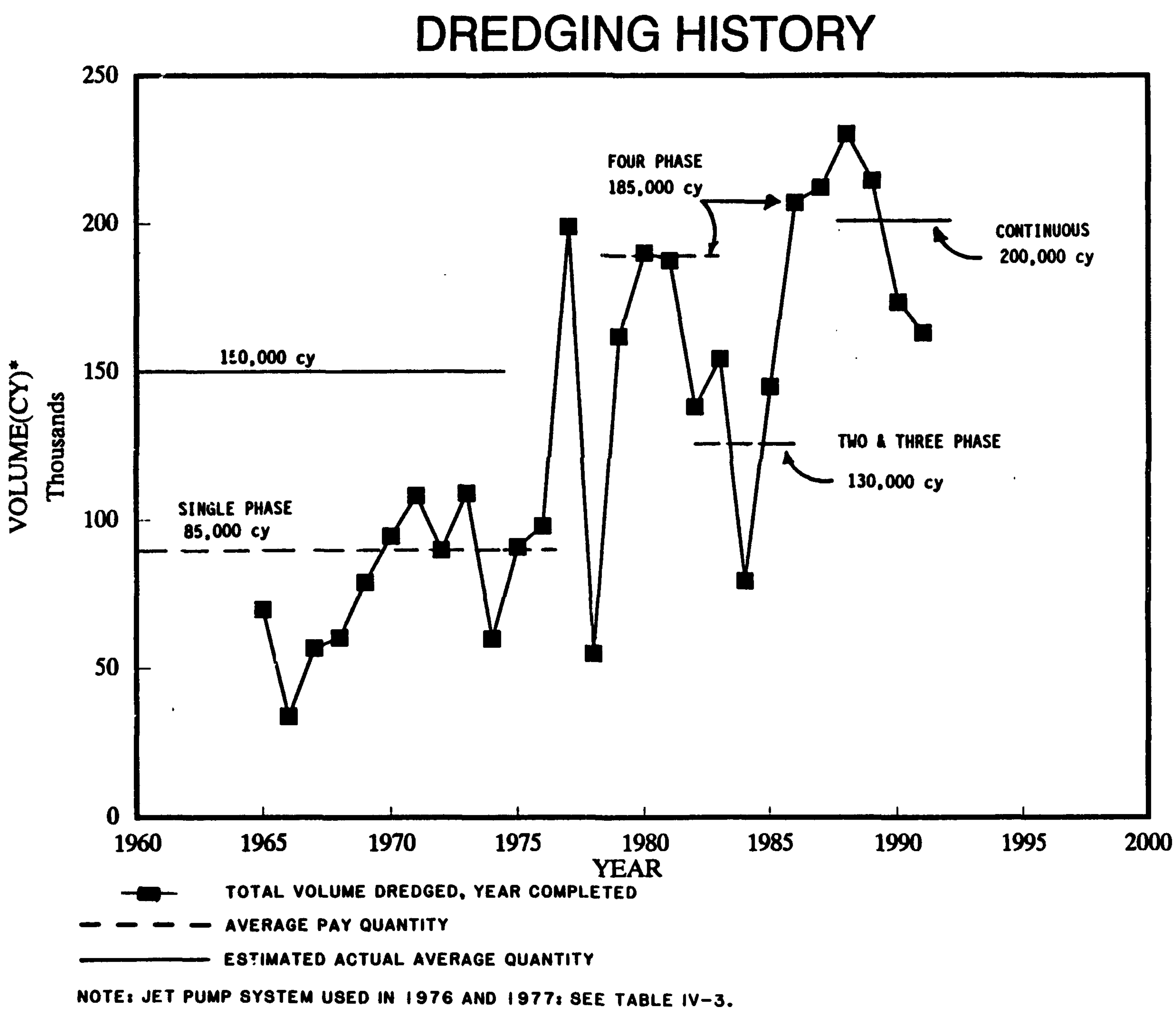


FIGURE IV-2



DREDGING HISTORY
VOLUME(CY)*
Thousands
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
YEAR
150,000 cy
SINGLE PHASE
85,000 cy
FOUR PHASE
185,000 cy
CONTINUOUS
200,000 cy
TWO & THREE PHASE
130,000 cy
TOTAL VOLUME DREDGED, YEAR COMPLETED
AVERAGE PAY QUANTITY
ESTIMATED ACTUAL AVERAGE QUANTITY
NOTE: JET PUMP SYSTEM USED IN 1976 AND 1977; SEE TABLE IV-3.

FIGURE IV-3

POTENTIAL SURGE AMPLIFICATION

SANTA CRUZ HARBOR

INITIAL CONFIGURATION

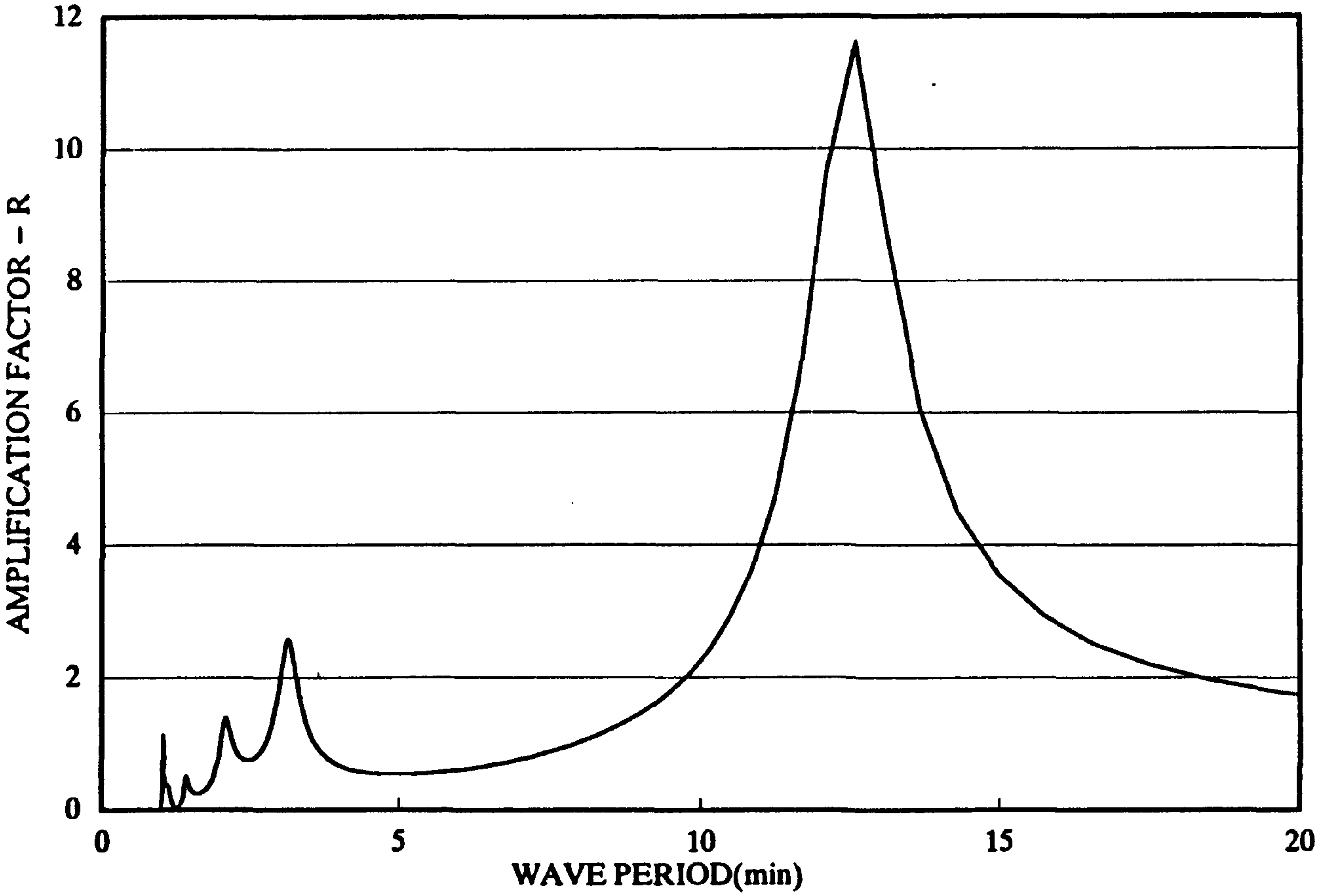


FIGURE V-1

POTENTIAL SURGE AMPLIFICATION

SANTA CRUZ HARBOR

PRESENT CONFIGURATION

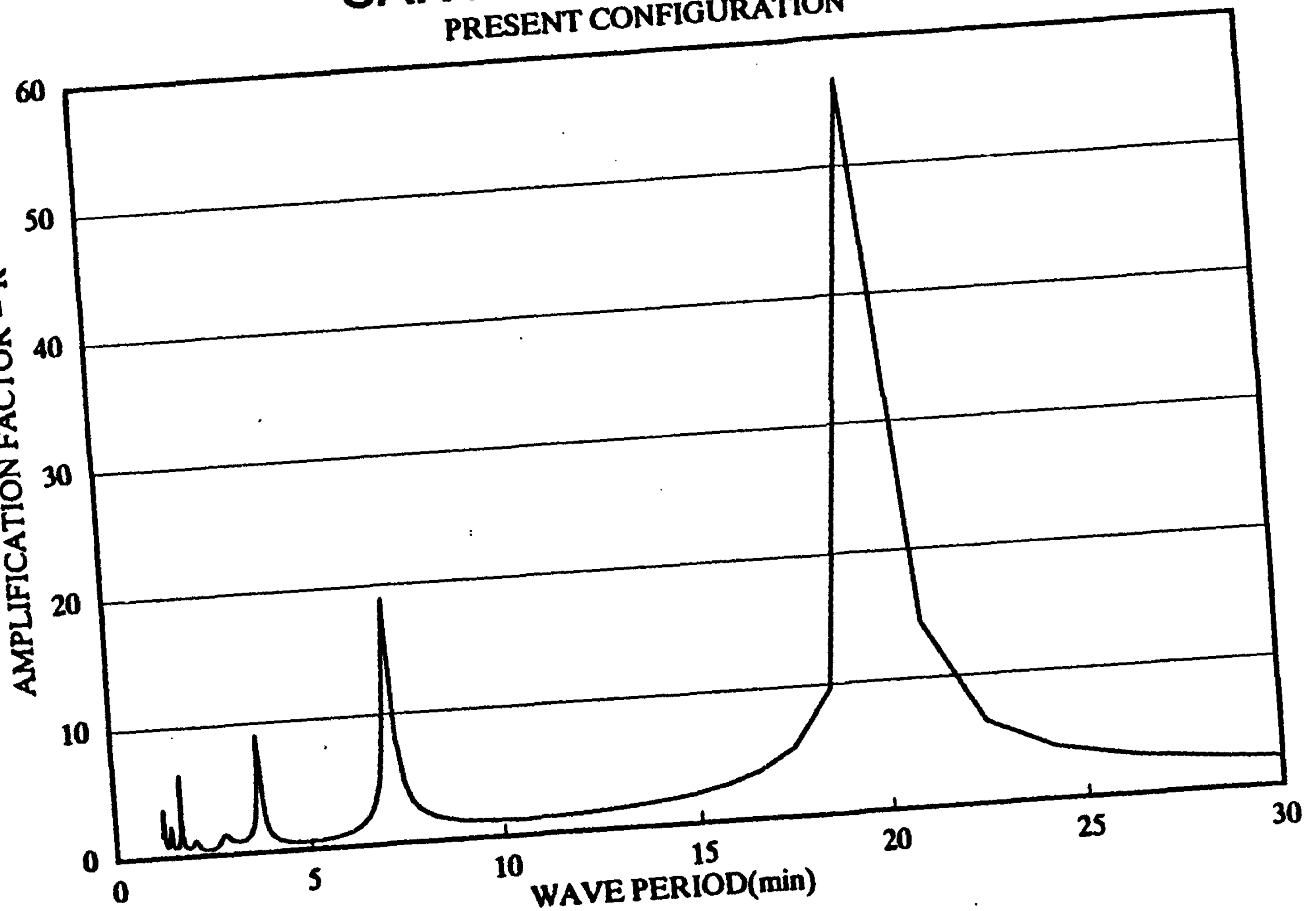
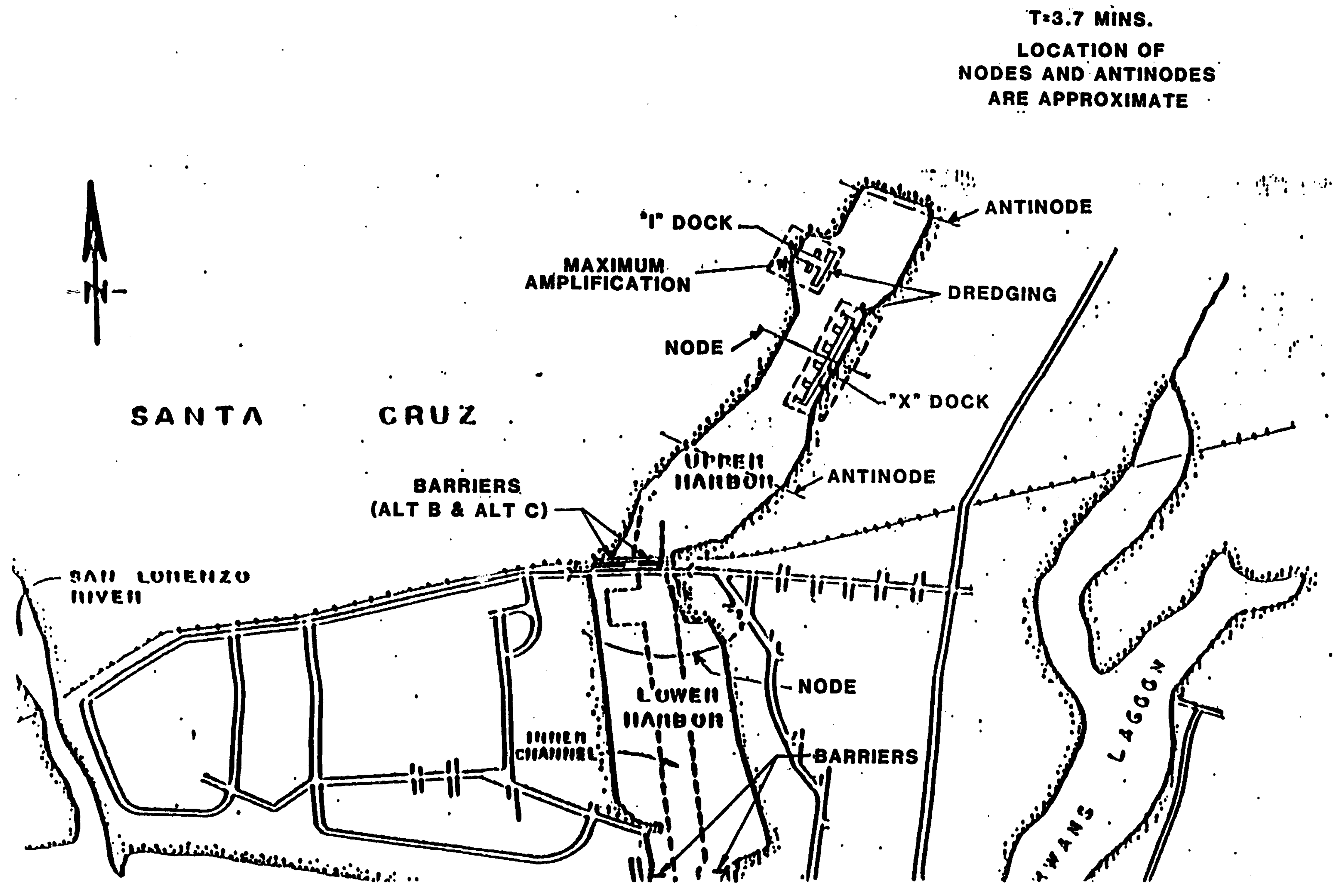
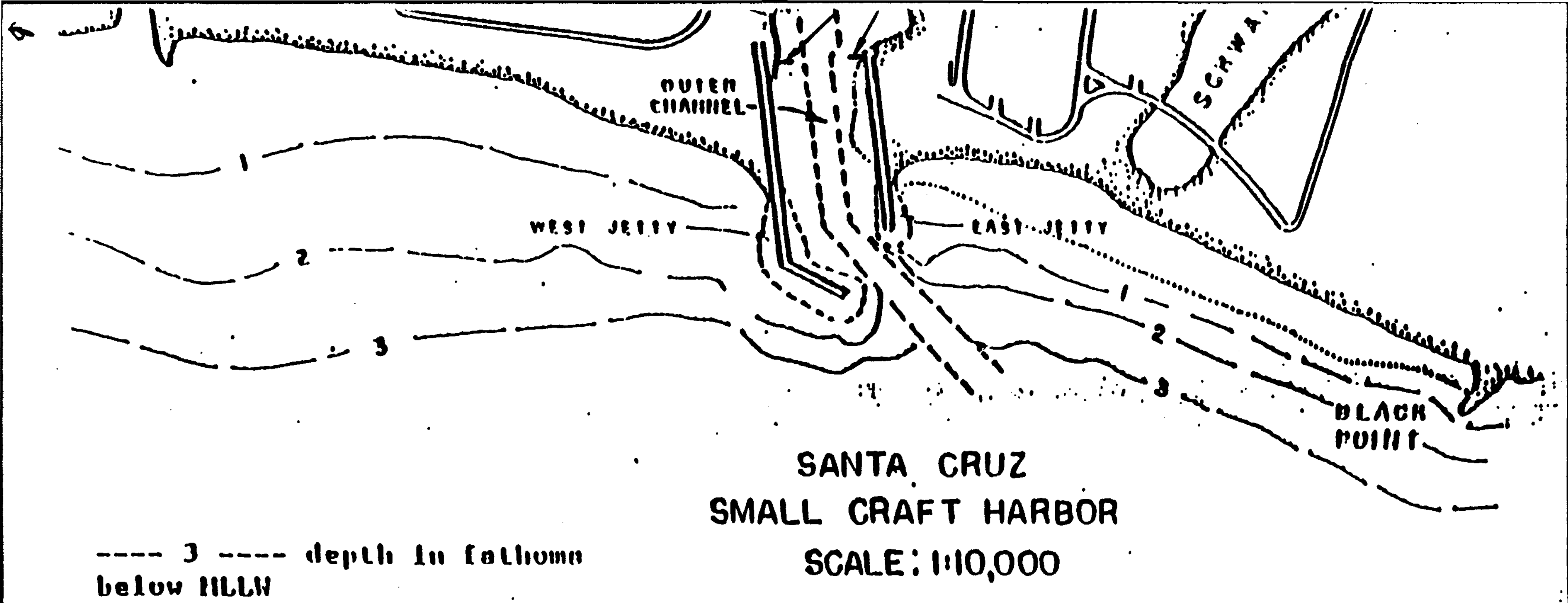


FIGURE V-2

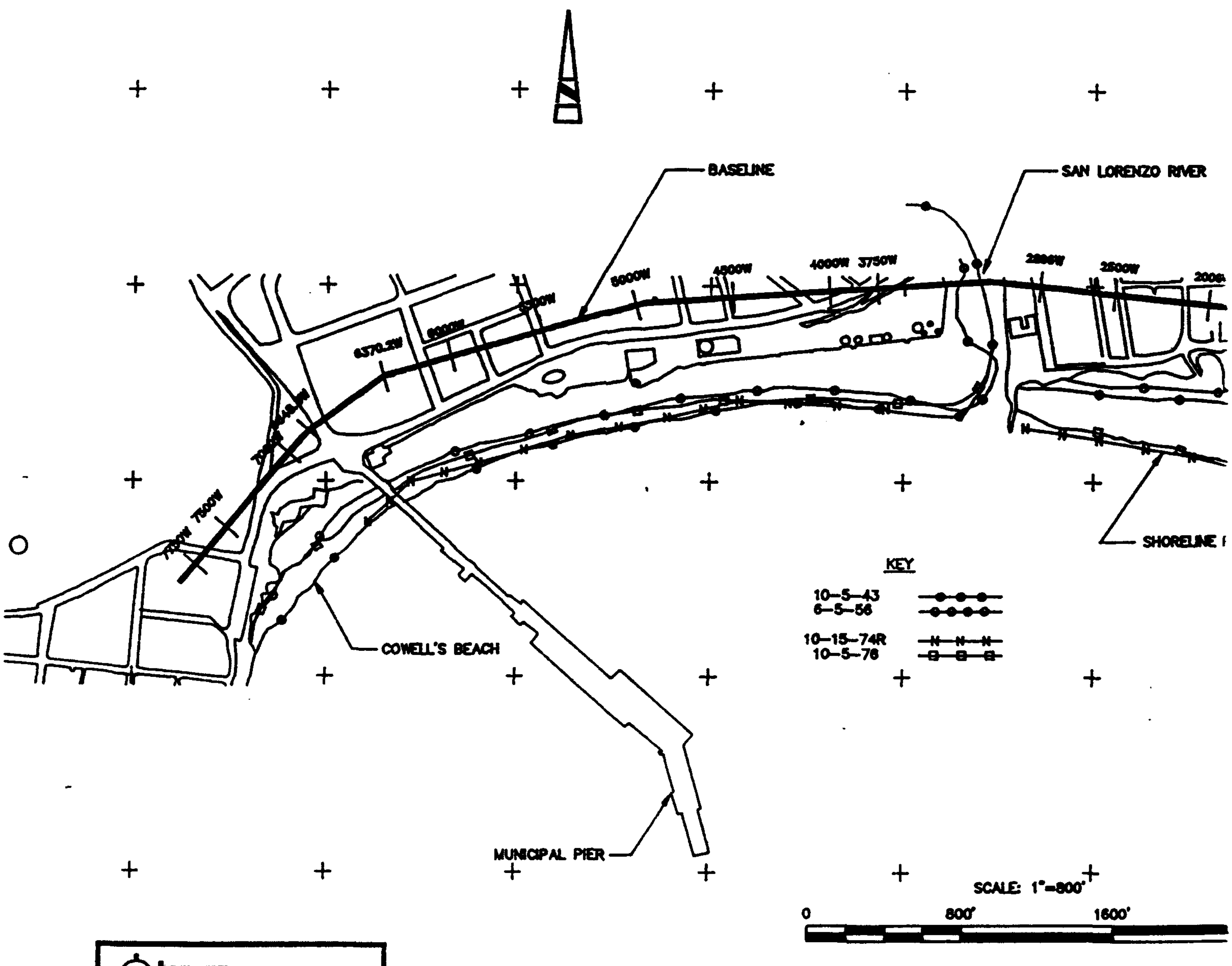

T=3.7 MINS.
LOCATION OF
NODES AND ANTINODES
ARE APPROXIMATE
ANTINODE
"I" DOCK
MAXIMUM
AMPLIFICATION
DREDGING
NODE
"X" DOCK
SANTA CRUZ
UPPER
HARBOR
ANTINODE
BARRIERS
(ALT B & ALT C)
SAN LORENZO
RIVER
NODE
LOWER
HARBOR
INNER
CHANNEL
BARRIERS
LAGOON
N



MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

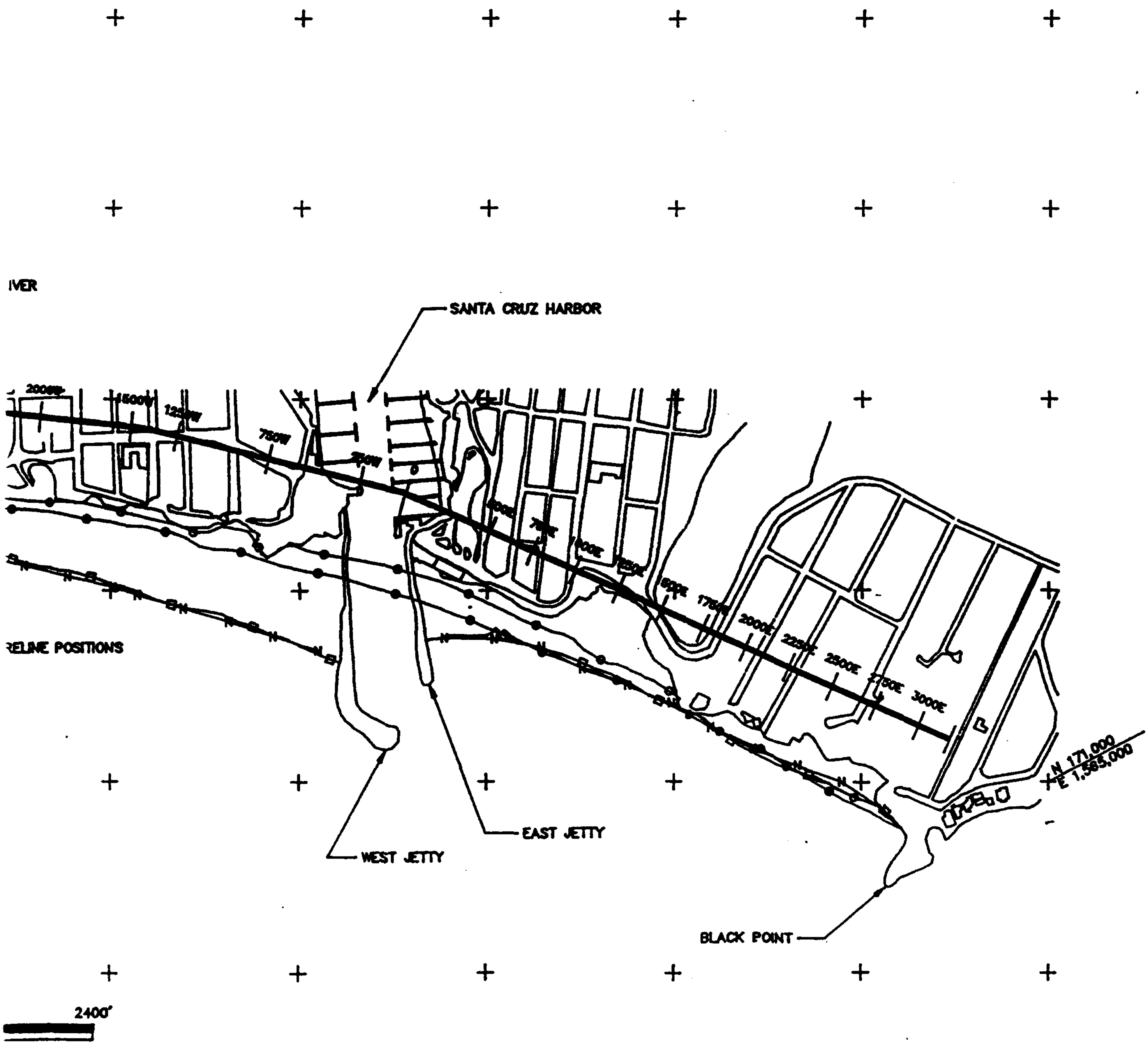
FIGURE V-3: ALTERNATIVE CONCEPTS TO REDUCE SURGE IMPACTS

VIII. TECHNICAL APPENDIX, SHORELINE DATA



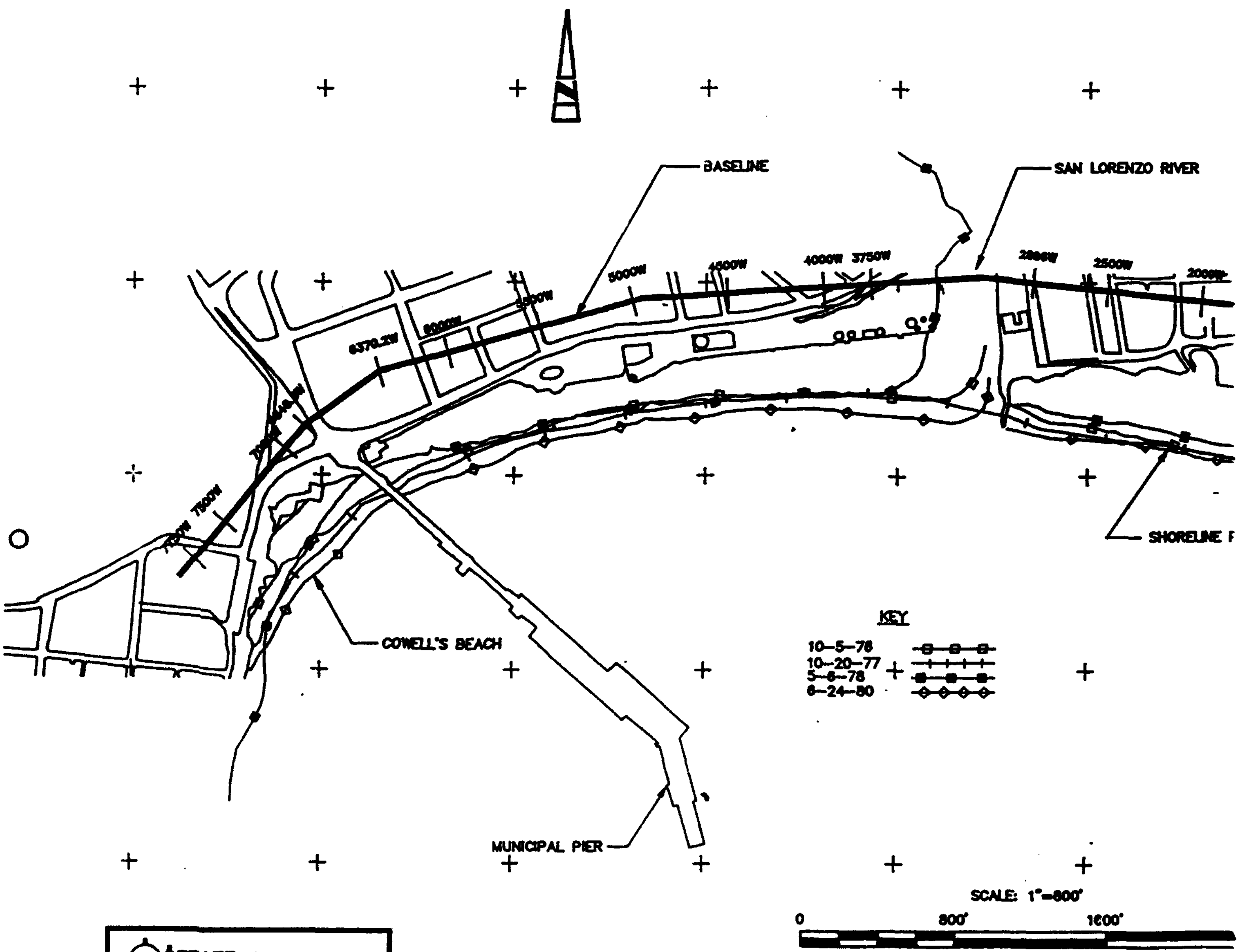
MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

FIGURE A1; SHORELINE POS
COWELL'S BEACH TO



OSITIONS, 1943 TO 1976.
'O BLACK POINT.

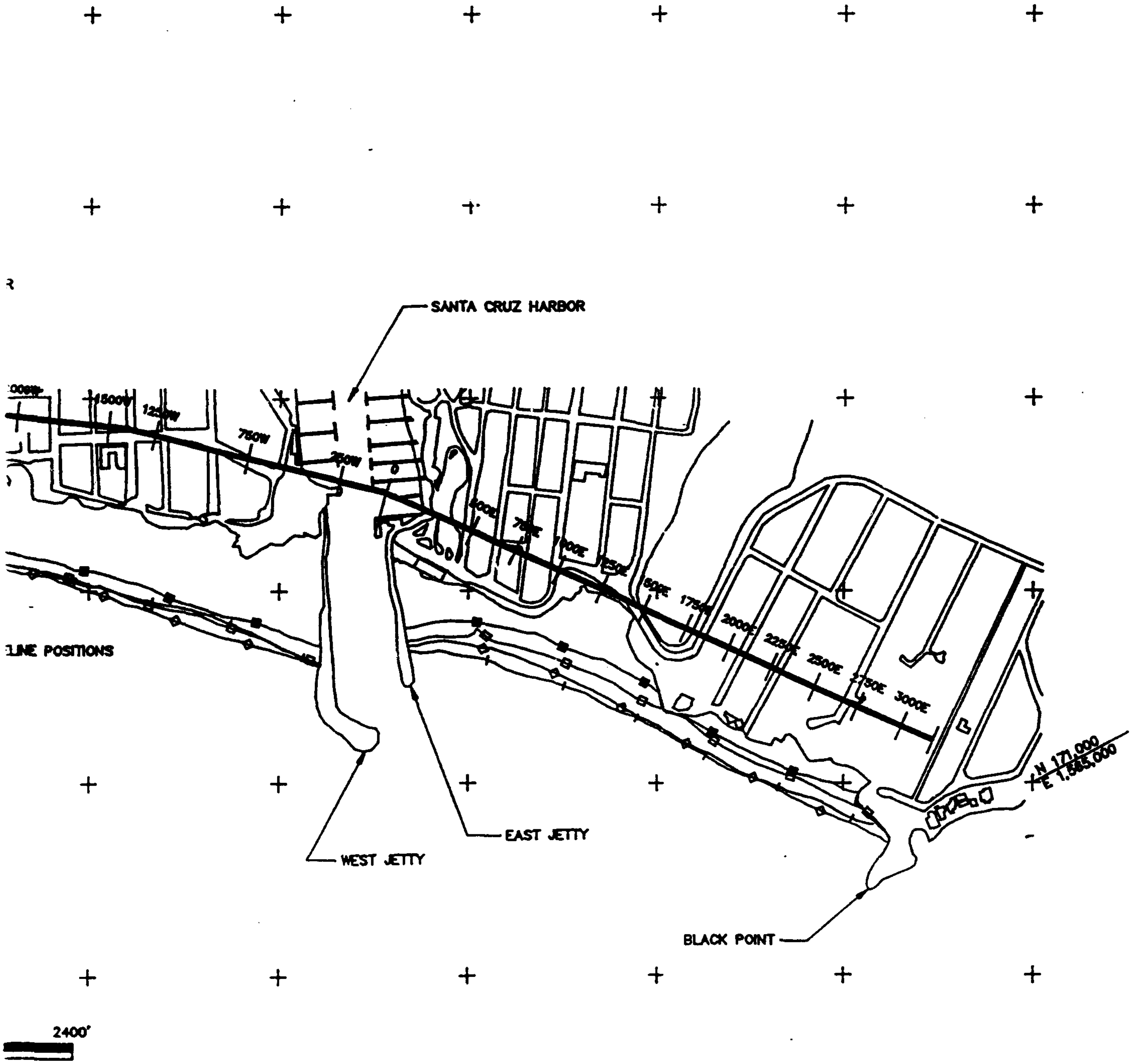
.B



MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

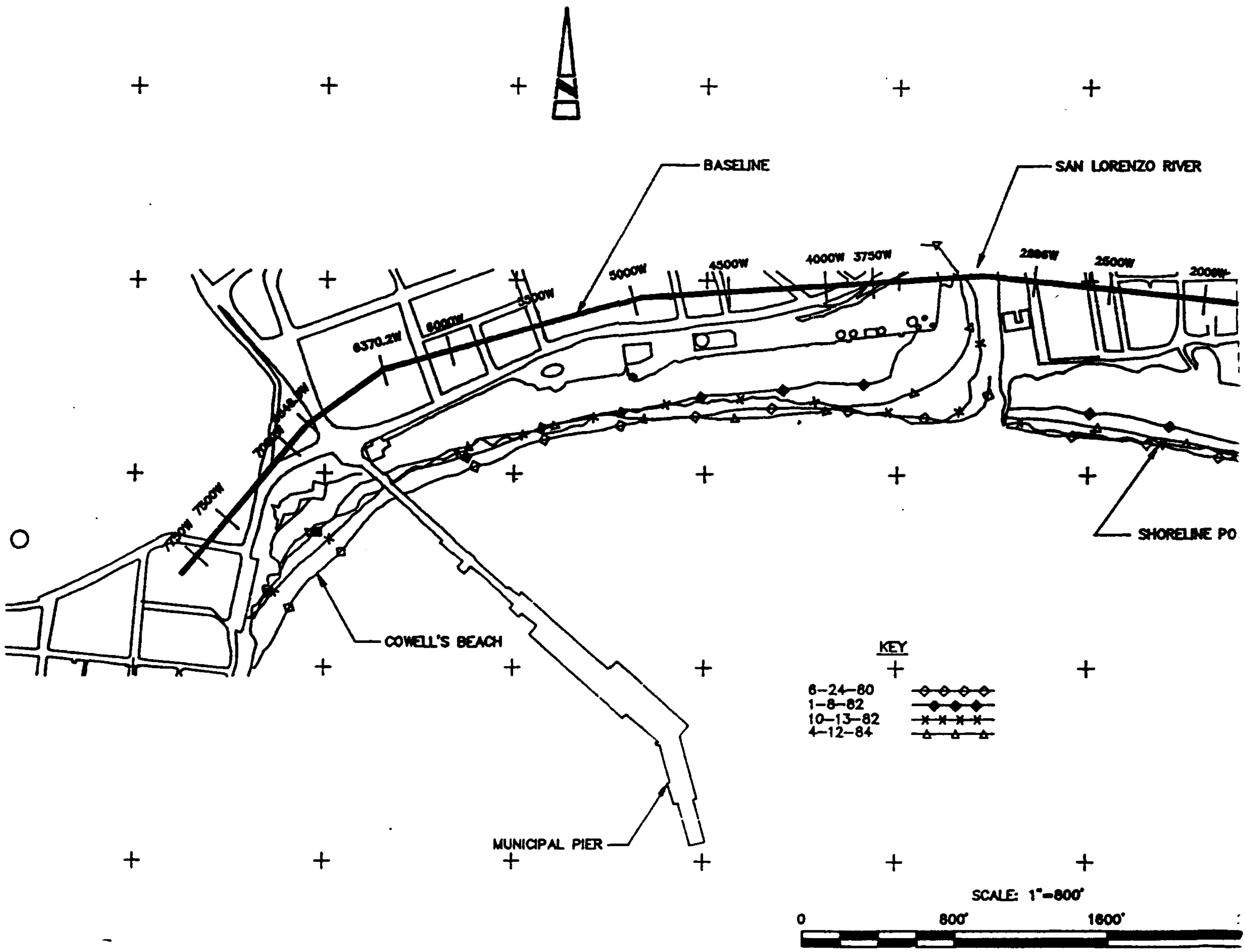
FIGURE A2; SHORELINE POS
COWELL'S BEACH TO BI

A



OSITIONS, 1976 TO 1980.
BLACK POINT.

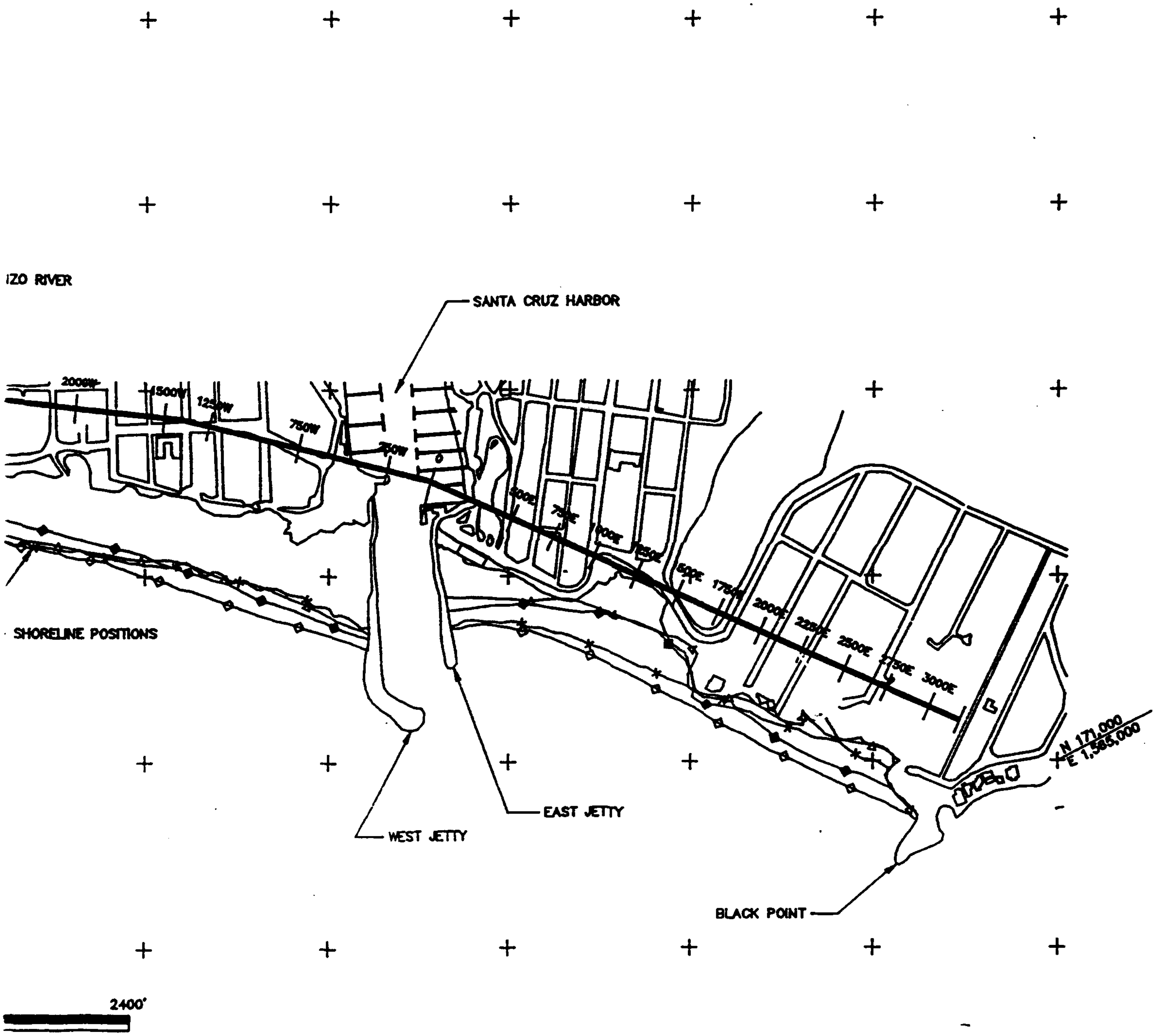
b



MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

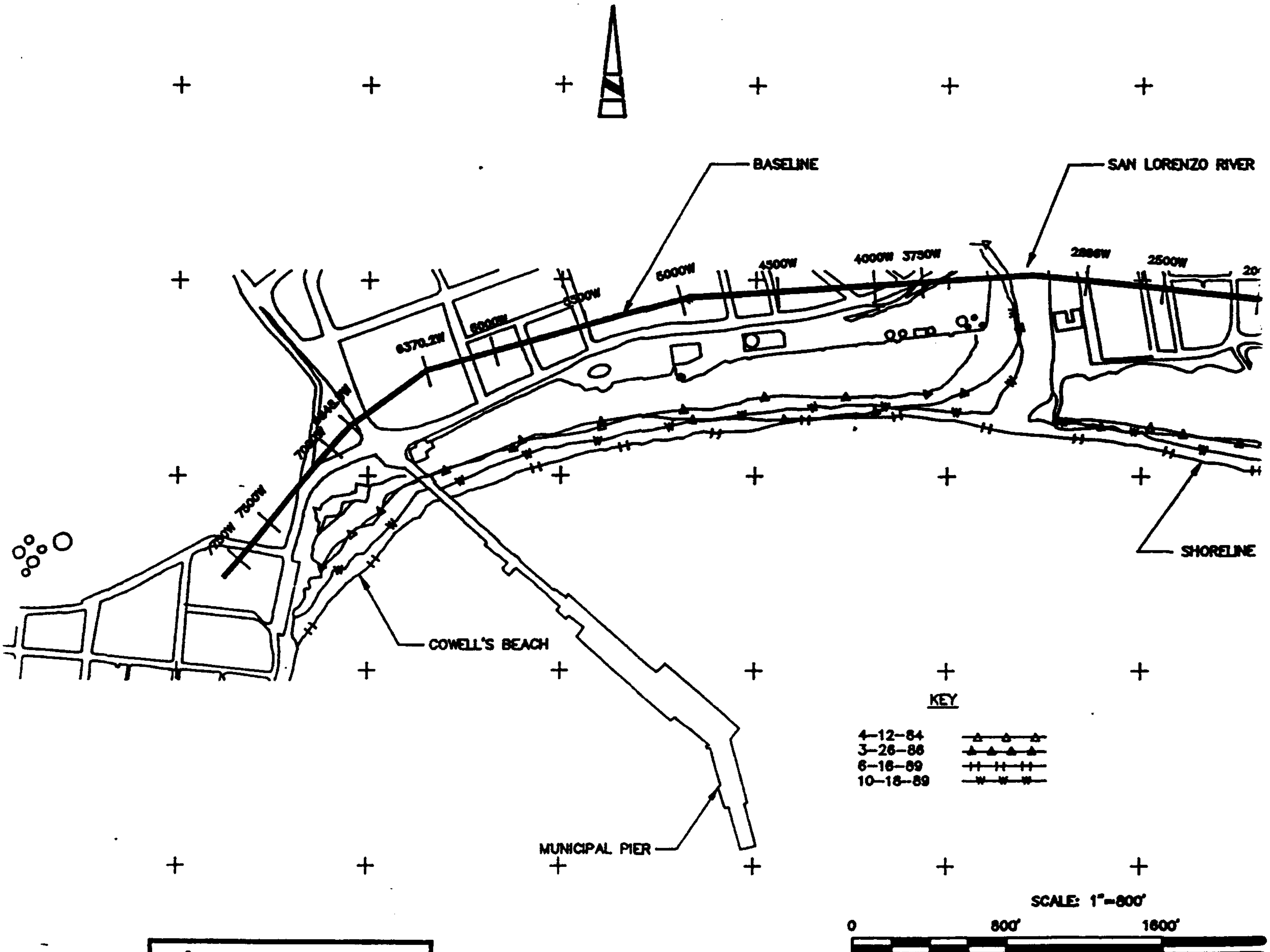
FIGURE A3; SHORELINE POSI
COWELL'S BEACH TO

A



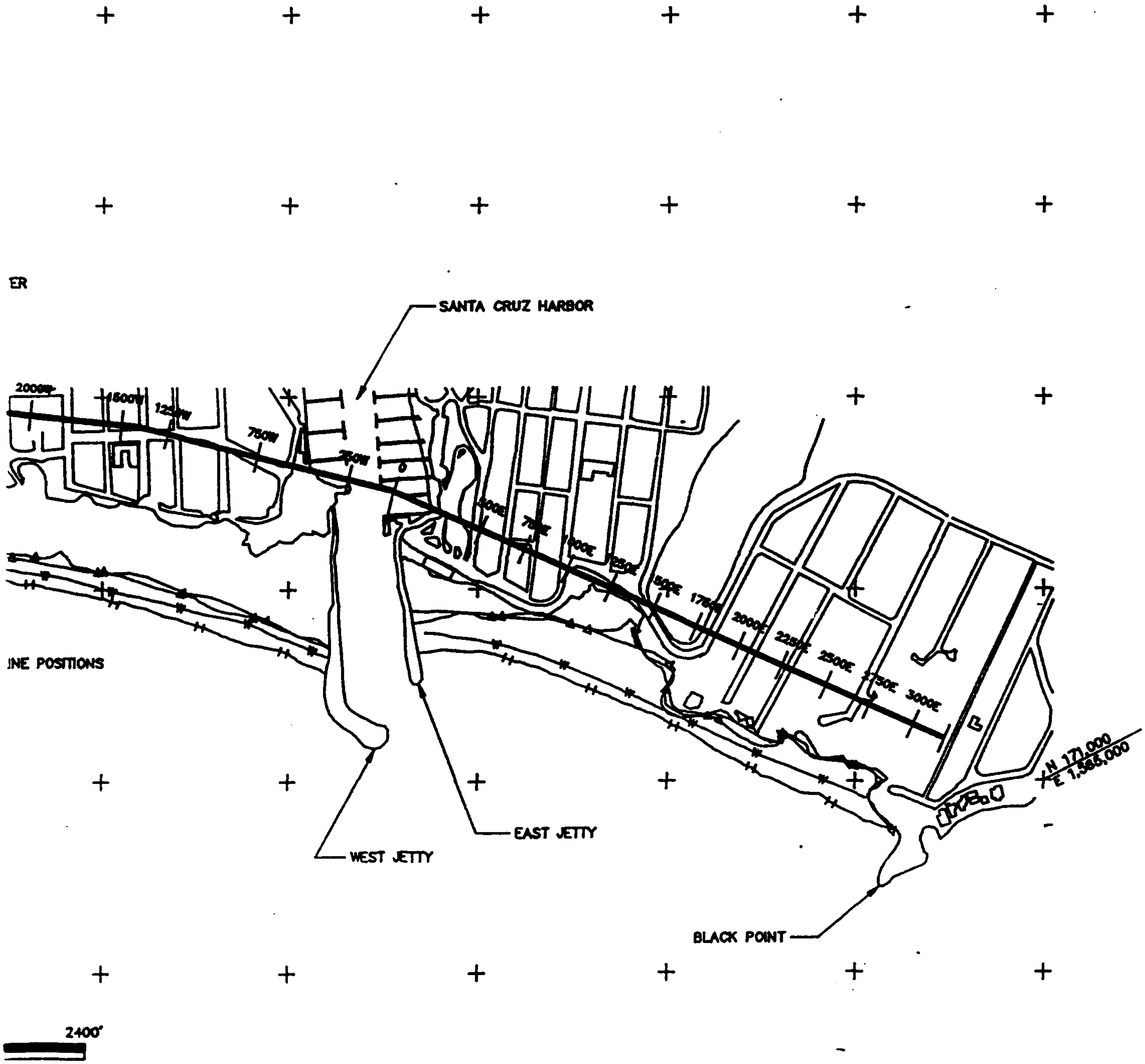
POSITIONS, 1980 TO 1984.
TO BLACK POINT.

B



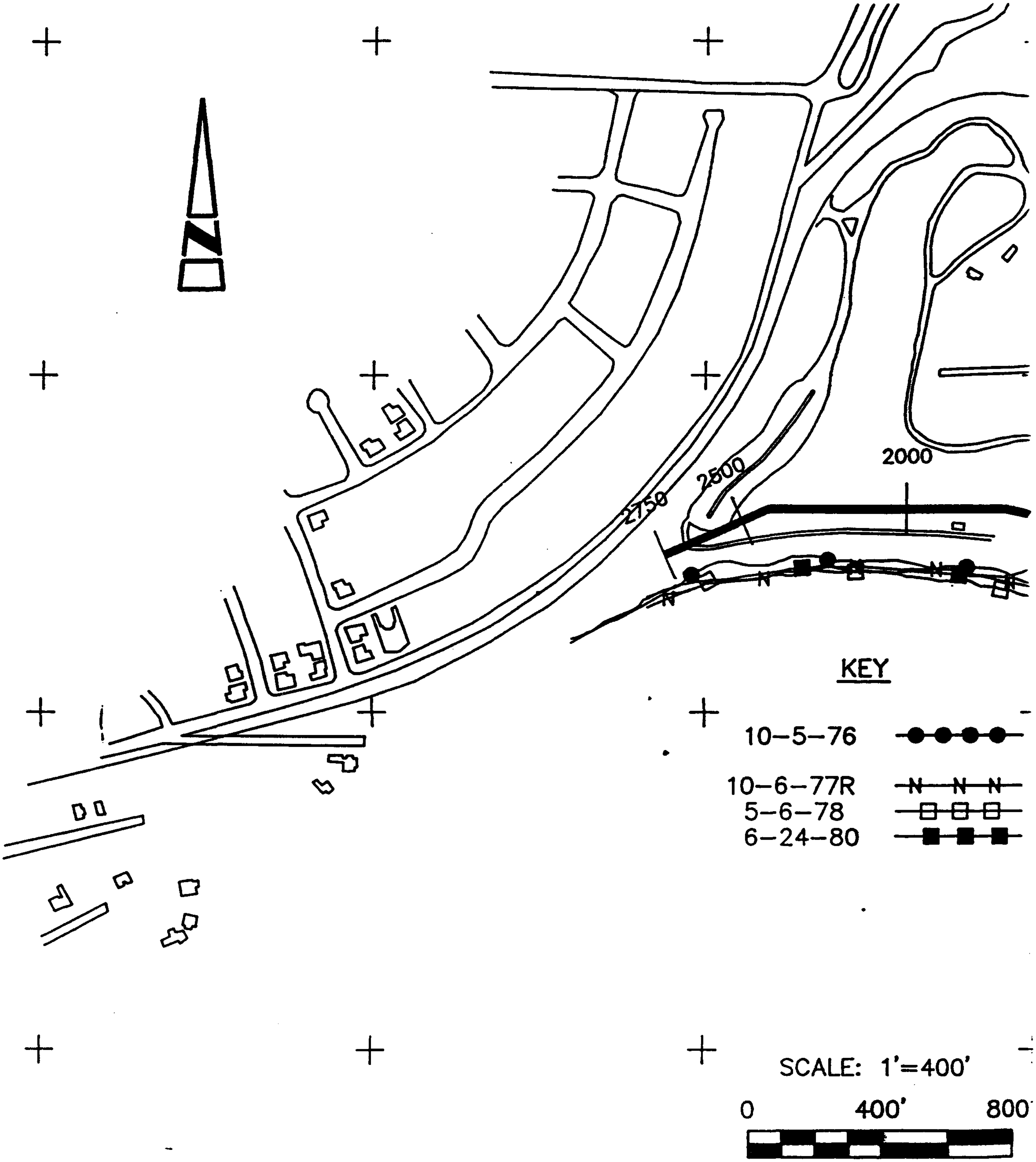
MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

FIGURE A4; SHORELINE PC
COWELL'S BEACH T



OSITIONS, 1984 TO 1989.
TO BLACK POINT.

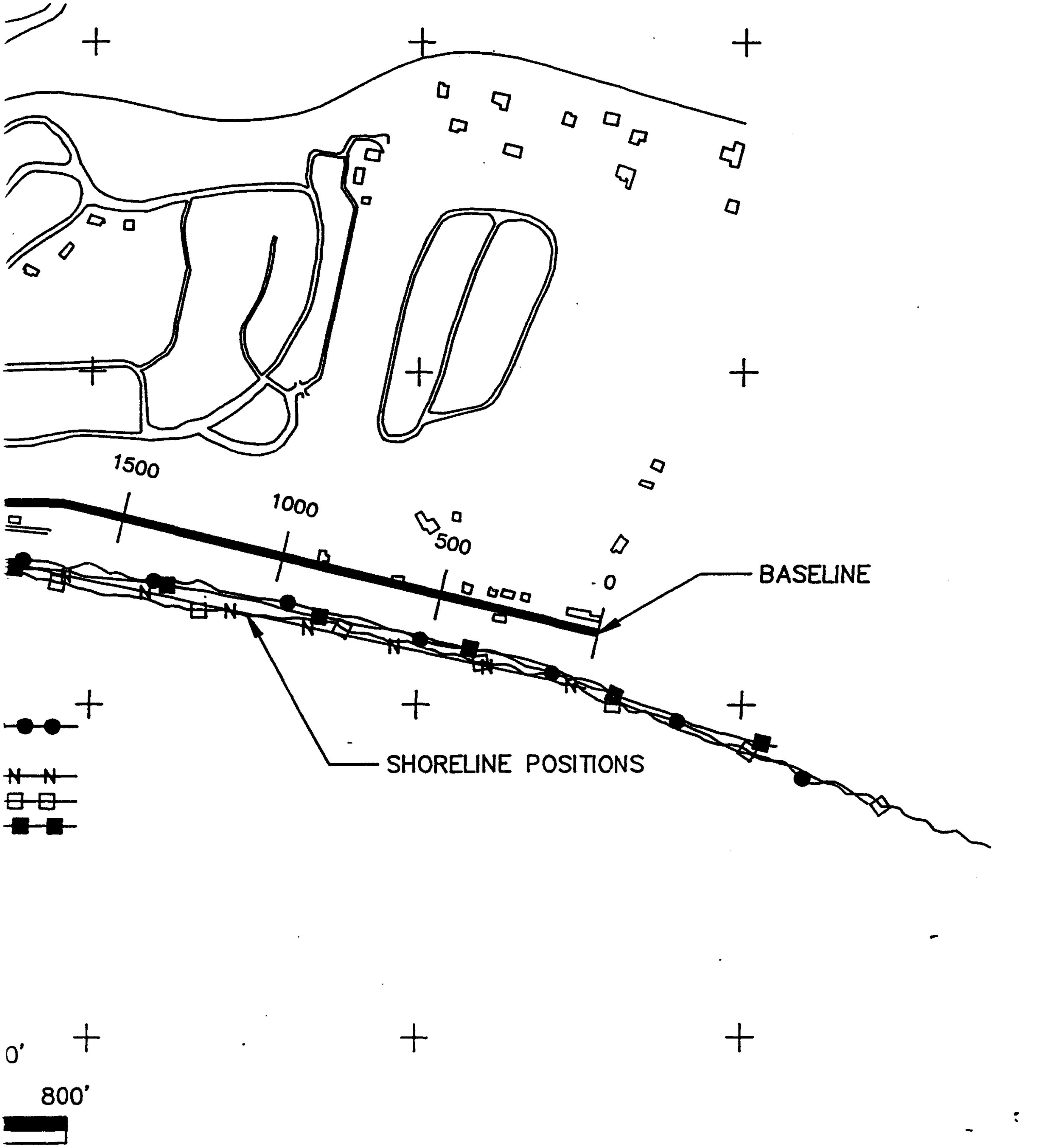
b



MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

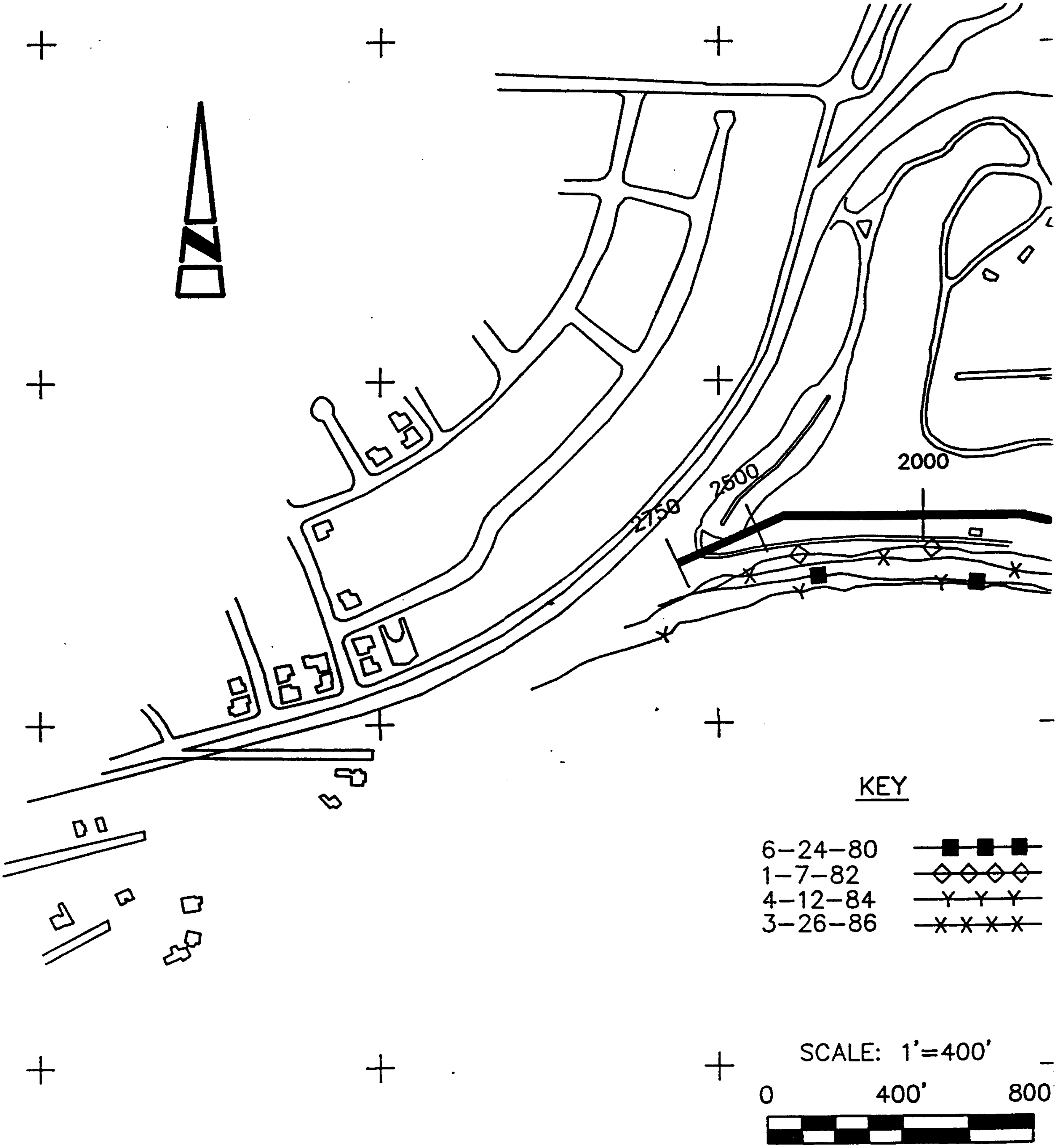
FIGURE A5; SHORELINE POSITIC

NEW BRIGHTON BI



SITIONS, 1976 TO 1980.

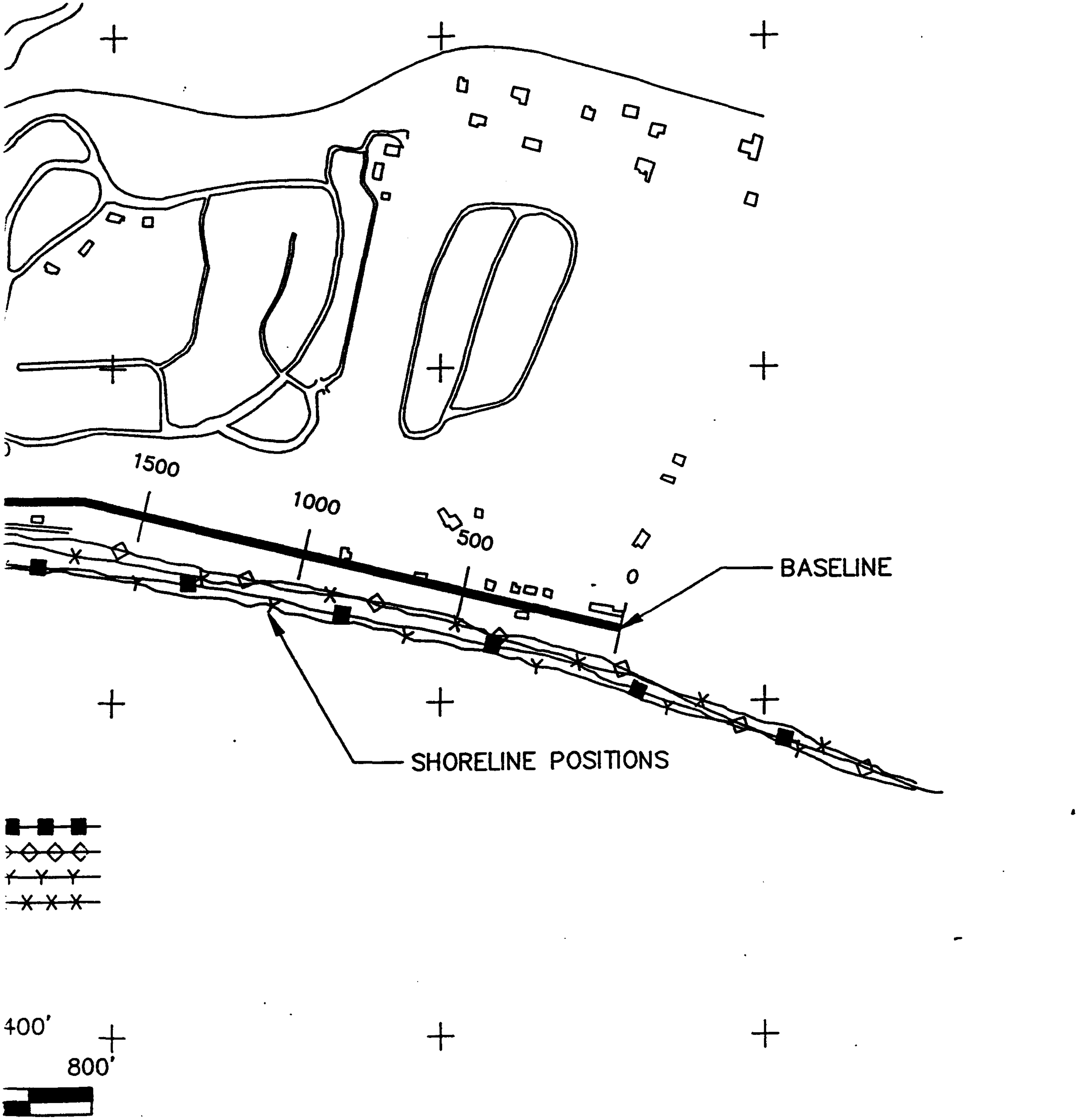
N BEACH



MOFFATT & NICHOL, ENGINEERS
SAN FRANCISCO, CALIFORNIA

FIGURE A6; SHORELINE POSITI(

NEW BRIGHTON B



SITIONS, 1988 TO 1986.

N BEACH

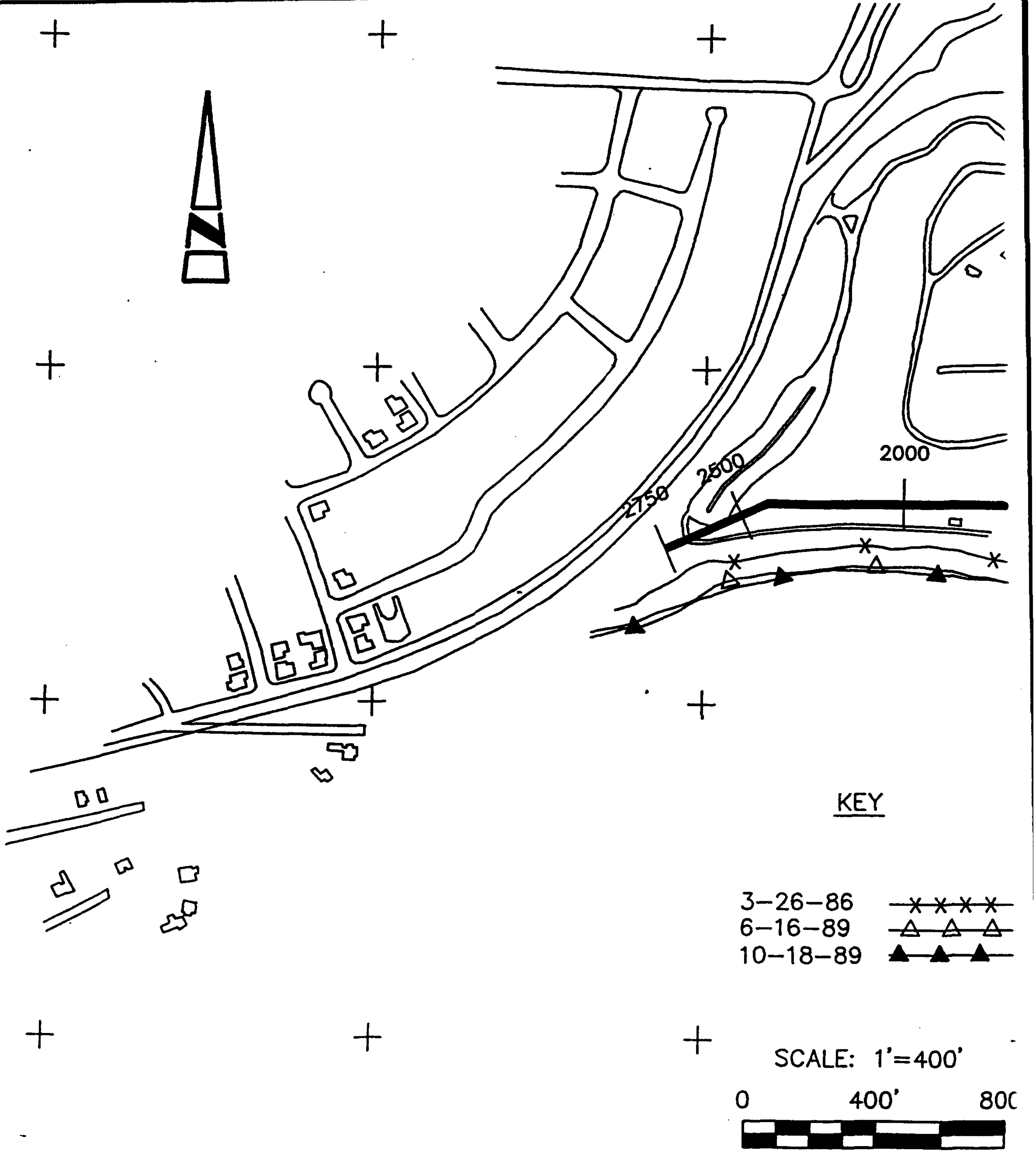
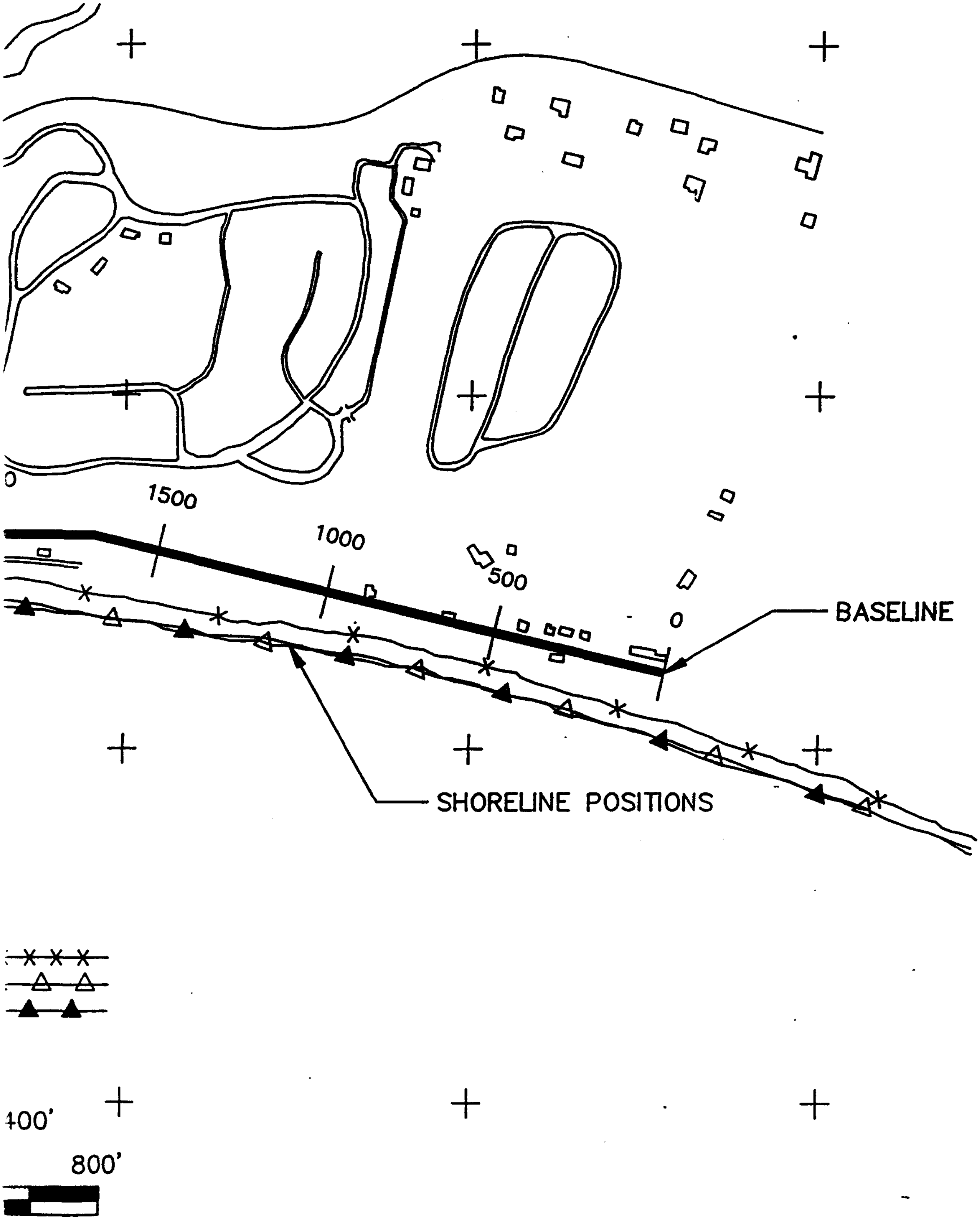


FIGURE A7; SHORELINE POSITI

NEW BRIGHTON B



)SITIONS, 1986 TO 1989.

)N BEACH

Appendix C

Environmental Assessment

US Army Corps
of Engineers
San Francisco District

PRELIMINARY ENVIRONMENTAL ASSESSMENT
SANTA CRUZ HARBOR SHOALING STUDY

April 1992

CONTENTS

1.0 STUDY AUTHORITY

Authority for this study comes from the Congress of the United States in section 811 of the Water Resources Development Act of 1986 (PL 99-662) which states:

> "The Secretary shall conduct a feasibility study of the long-term solutions to the shoaling problems in Santa Cruz Harbor and shall report the results of such study, along with recommendations, to the Congress."

2.0 NEED FOR THE PROPOSED ACTION AND BACKGROUND INFORMATION

Santa Cruz Harbor, located at the northern end of Monterey Bay, has a chronic problem with shoaling at the harbor entrance. Normally, open ocean waves approach the bay from the northwest. As such, there is some protection afforded by the headland at Point Santa Cruz and by the jetties. However, storm waves from the southwest and refracted waves from the west and northwest transport in excess of 300,000 cubic yards of sand annually across Santa Cruz Harbor. Much of this sand enters the harbor and clogs the entrance.

The River and Harbor Act of 1958 authorized the construction of a small craft harbor in Woods Lagoon. Construction of this boat basin was completed in 1963. In 1983, the west jetty was sealed to prevent the passage of sand fluidized by wave action through the spaces between both the armor and underlayer stone. Up to 6,000 cubic yards of sand passes through the voids in the east jetty annually. Although sealing of the east jetty has been authorized, the project has not been undertaken. A 16-inch diameter suction dredge was acquired by the Port District in 1986. This dredge operates 80 to 100 days during the fall and winter months removing 160,000 to 235,000 cubic yards of sand. Sand removed from the channel is placed on the beach east of the harbor.

In spite of this intensive maintenance, the combined effects of storm waves and high sand transport can make the harbor unnavigable for a part of the winter. These processes contribute to the accretion of sand into a bar at the tip of the west jetty. This bar causes waves to shoal and break across the harbor entrance causing a hazard to navigation.

3.0 ALTERNATIVES

3.1 East Jetty Sealing

This alternative attempts to limit the transport of sand through interstitial spaces by flushing the sand from the core and replacing the sand with a sealant. Concrete would be pumped into the center of the distal 100 feet of the jetty. Three hundred fifty feet of the east side of the jetty would then be face sealed with concrete.

3.2 Dredge Pipe Extension

Lengthening the dredge pipe and the subsequent deposition of sand further eastward toward Black Point may prevent sand redeposition in the harbor by waves approaching from the south and southeast.

3.3 Channel Sand Trap

The excavation of sand down to the clay layer under the sand to form a temporary storage pit in the lee of the west jetty would accumulate sand in a convenient location. This will increase the amount of time the dredge would be in operation, increasing its output.

3.4 Offshore Sand Trap

The offshore sand trap alternative would dredge an excavation 2000 feet long roughly along the 25-foot isobath and landward to the 15-foot isobath in front of the west jetty and the harbor entrance. Annually, up to 200,000 cubic yards of sand would be removed from the shoal area in front of the harbor and disposed of one mile to the east in a one-third mile long area between the 15-foot and 20-foot isobaths near Corcoran Lagoon. This disposal site is expected to be dispersive and close enough to shore to keep the sand in the downcoast littoral system.

3.5 Fixed Jet Pump

The deposition of sand in the harbor entrance would be alleviated by placing a sand passage device in the channel. The sand would be pumped on to the beach eastward in a fashion similar to the existing dredge operation. This option would ease the burden on the dredge and permit faster clearing of the harbor after storms. This option entails the placement of a second pipe parallel to the dredge pipe currently in use. A permanent building to house the pump on the west jetty, and some accessory structures for piping and wiring will need to be constructed.

3.6 Mobile Jet Pump

This alternative attempts to bypass sand to the east beach before it can accumulate in the harbor. The structures, piping and wiring for this alternative are similar to those of the fixed jet pump. In this scenario, the eductor nozzle will be deployed in the intertidal zone on Seabright Beach. The eductor nozzle and piping will be placed, maneuvered, and retrieved with a crane mounted on a tracked or wheeled vehicle daily during the dredging season.

3.7 No Action

Sand movement would continue, and the Santa Cruz Port District would continue maintenance dredging. The dredging operation may be extended or upgraded to remove more sand minimizing the safety hazard and harbor closures.

3.8 Other Alternatives

A combination of one or more of the listed alternatives could be applied to the problem.

4.0 ENVIRONMENTAL SETTING

4.1 General

The climate of the Monterey Bay area here has been described as coastal Mediterranean. Relatively stable water temperatures combined with the upwelling and nutrient mixing from the Monterey Canyon make the ocean highly productive. Thus, the area supports a wide variety of marine and terrestrial life. This mild climate and richness of resources has facilitated human habitation and exploitation of the region. The earliest known evidence, dated around 8,000 BC, is attributed to the Castanoan Indians.

EuroAmerican contact with the region was first documented by the Portola Expedition which passed by in 1769. Early settlement was focused well inland around the Mission la Exaltacion de la Santa Cruz. This mission was consecrated in 1791 near the San Lorenzo River in the vicinity of River Street and North Pacific Avenue. In the nineteenth century, the mission system was displaced by the combined effects of the industrial revolution and the policy of manifest destiny.

Today, agriculture is still the predominant land use in the Santa Cruz area. Modern times has also brought development for residential, commercial, light industrial, educational, and recreational purposes.

Santa Cruz Harbor is situated at the northern end of Monterey Bay, California, between Point Santa Cruz and Soquel Point. This portion of the Bay has a mixed sand, mud, and rock bottom with groves of kelp.

4.2 Study Area

The study area is a semi-protected, open coast sand beach environment situated on old marine terrace deposits known as the Purisima Formation. The beach is roughly a mile in length and is bisected by the harbor. The study area

is physically bounded at either end by two sandstone promontories which protrude from the cliffs and extend into the surf zone. The landward boundary of the beach is sandstone cliffs that have weathered and eroded in an irregular fashion. These cliffs vary in height from a few feet to roughly 50 feet and show evidence of undercutting by wave action.

Residential development predominates on the cliffs. Where natural processes have reduced the cliffs landward, there is development for recreational access to the beach by municipal and state agencies. In the immediate vicinity of the harbor, natural processes have had the greatest effect and the flatter terrain supports commercial and retail businesses. The area affected by the project extends eastward from the mouth of the San Lorenzo River to Black Point, a distance of approximately one mile. The study area is 33 acres and is almost entirely sandy beach. Sandstone cliffs of the Purisima formation form the landward boundary of the study area. The sandstone cliffs have been undercut by wave action in several places. The western boundary is a sandstone promontory located on the east bank of the San Lorenzo River. Black Point, the eastern limit of the beach, is a similar, but larger geologic feature.

The Santa Cruz small craft harbor bisects this beach. The harbor is used by commercial and recreational vessels. The construction of the harbor with its jetties and the deposition of dredged sand on the east beach have slowed the longshore transport of sand and has allowed the growth of the beaches on either side of the harbor. Some small, lightly vegetated dunes are present on the west beach.

The beaches on either side of the harbor have been developed primarily for recreation. The western section is Seabright, a municipal beach. There is one restaurant at Seabright Beach.

Twin Lakes State Beach is on the eastern side of the harbor. Here, the sandstone cliffs are substantially eroded and the beach somewhat wider. There are several retail businesses adjacent to the harbor and the state beach. At the eastern end of the study area, kelp is plentiful enough to support commercial harvest just outside of the surf zone.

Woods Lagoon was not historically used for navigation. Landings were established as early as 1849 at the mouth of Soquel Creek and the San Lorenzo River, the latter being the site for considerable trade in the mid-nineteenth century. A number of shipwrecks have been reported proximal to the project area.

4.3 Project Area

The boat basin at Santa Cruz Harbor is the dredged and channelized estuary of Woods Lagoon. The beaches on either side of the harbor and the harbor entrance are directly affected by the presence of the harbor and its maintenance dredging.

4.4 Vegetation

The vegetation at Santa Cruz Harbor is a mixture of native and introduced plants. The native species are those which typically colonize beaches, dunes, and sea cliffs. Other natives and exotics present are those which can thrive in exposed, barren, or disturbed soils. The east beach is devoid of vegetation except along the jetty and along the base of a low cliff shelf. On the west beach, vegetation can be found along the jetty and at the foot of the cliffs. A small area near the jetty has begun to accrete sand and small vegetated sand dunes are forming. There are no trees on the beach; those on the cliffs are pine, cypress, eucalyptus and various ornamentals.

4.5 Wildlife

A great many species of birds may be observed at Santa Cruz Harbor. The principal users of the beach are sanderlings, short-billed dowitchers, and immature and adult gulls of several species. During the dredging season, the gulls congregate near the dredge pipe and forage on the carrion discharged along with the sand. Spiny sand crabs and sea squirts are the common victims of dredging. Sanderlings and dowitchers routinely forage in the receding surf; an indication that the sand dwelling crustaceans of the open coast are present.

Harbor seals and California sea lions are frequently seen seaward of the surf zone. Sea otters and Steller's sea lion are casual visitors to the area. None of these marine mammals depend on the project area harbor. Five species of whales are commonly seen along the central coast.

4.6 Fish & Invertebrates

Pieces of kelp and invertebrate shells cast upon the beach suggest a nearshore bottom community that shifts from a high energy sandy beach environment to kelp forest with a mixed sand/mud/rocky zone between them. Just offshore, kelp is commercially harvested. Limpets, red algae, green algae, barnacles and mussels colonize surfaces of the quadripods and rocks of jetties.

Jetty fishing for surfperch is popular in the project area from February to April. Skiff and charter boat fishing for bottom fishes takes place year round in Monterey Bay. Principal species are the rockfish and flatfish groups. When oceanographic conditions are favorable, salmon, tuna, and some of the pelagic game fishes may be caught.

4.5 Cultural Resources

There are number of historical sites in the Santa Cruz area. None of these are located in the study area. The possible existence of prehistoric sites is

more complicated. Changes in sea and land levels over geologic time bury or drown sites and artifacts. Recent comparisons of maps and the results of geologic surveys show that the erosive forces of nature are significantly reducing the coastline. Because of this, and because the larger part of the study area was either intertidal or open water prior to the construction of the harbor, the Pacific coast proximal to the project area is considered to be devoid of any cultural resources.

4.6 Socio-Economic

The Santa Cruz Port District is an independent agency created in 1950 under provisions in the Harbors and Navigation Code of the State of California. The District is governed by a board of five commissioners who are elected at large by voters residing in the Port District. Revenue from slip rentals, user fees, and concessions fund 90% of the district's operating budget. The remaining ten percent comes from property taxes.

The City of Santa Cruz is heavily marine oriented. It's central business district and the waterfront are bisected by the course of the San Lorenzo River which enters the Pacific Ocean in Santa Cruz Harbor. Marine research, commercial fishing, and water-related recreation are prominent activities.

The mild climate and scenic beauty of Santa Cruz combined with the richness and variety of marine life in Monterey Bay attract visitors and commerce from the central California area.

The growth of the City of Santa Cruz is typical of the region, with a population of 26,000 in 1960, expanding to over 50,000 in 1990. Ethnicity in 1990 was: 90% White; 13.6% Hispanic; 4.4% Asian/Pacific Island; and 2.1% Black. The City has estimated that in 1991, its recreation and park facilities served a population of over 100,000 people, and has estimated the tourist population to be 2.5 million annually.

5.0 ENVIRONMENTAL IMPACTS

5.1 No Action

Sand movement would continue and the Santa Cruz Port District would continue maintenance dredging. The dredging operation may be extended or upgraded. Since possible changes to the present dredging operation are not known, these environmental impacts cannot be predicted.

5.2 Vegetation

East Jetty Sealing: This alternative would have a slight impact on vegetation adjacent to the jetty and along the access corridor for construction equipment. Since there is hardly any vegetation in this area of the beach, and it is virtually all non-native species capable of rapid proliferation, this adverse impact will be temporary.

Dredge Pipe Extension: Lengthening the dredge pipe and the subsequent deposition of sand further east will have no impact on vegetation as there is none where the pipe would be placed. Near the jetty, the impact on the vegetation would be similar to that of the jetty sealing operation.

Channel Sand Trap: Any excavation of sand in reasonable excess of what is now being dredged will have no impact on the vegetation.

Offshore Sand Trap: This alternative will not affect the terrestrial vegetation in the project area because it is confined to the marine environment.

There are kelp forests in the vicinity of the sand trap and disposal sites. The turbid water resulting from suspended sediments may have adverse effects on the plants and animals in this community. Burial, displacement, and interruption of photosynthesis are possible, but the magnitudes of these effects are unknown.

At the sand trap site, this effect will be manifest only during the few weeks needed to accomplish the dredging. Effects at the disposal site will persist until longshore transport disperses the dredged material the and natural processes restore the benthic organisms.

This dredging would be repeated annually so it would be a continuing impact. Water clarity in dredge disposal areas quickly returns to normal, but the length of time for the sea floor to return to normal is unknown. The large quantities of sand disposed of each year may permanently alter the dump site.

Fixed Jet Pump: The operation of a sand passage device in the channel would not directly affect the vegetation. However, the placement of the device requires a staging area on the west beach, and some permanent construction, so there would be a slight impact to the vegetation similar to the jetty sealing alternative.

Mobile Jet Pump: The operation of a sand passage device in the intertidal zone would not directly affect the vegetation. However, the placement of the device requires operation of a crane on the west beach. Although the vegetation on the beach is slight, disturbance of the beach for several months a year by the movements of the crane would probably eliminate some vegetation along the access corridor used by the crane.

5.3 Wildlife

East Jetty Sealing: The impacts to wildlife would be the temporary loss of roosting spots for sea and shorebirds on and around the jetty and the permanent displacement of small mammals that might nest or forage in the drier recesses of the jetty. The effect on the birds will be brief and transitory. Because the population of small animals residing in the east jetty is not known, the impacts cannot be determined.

Dredge Pipe Extension: Lengthening the dredge pipe and the subsequent deposition of sand further east will have no impact on wildlife except to those shorebirds that forage along the beach. Broadly speaking, these birds are of two types: gulls and sandpipers. The gulls which forage for carrion in the dredged sediment will simply follow the food source. The sandpipers feeding in the receding surf will move and forage in an area of the beach in which the small crustaceans they seek are plentiful. When the deposition of dredged sand is finished in a segment of the beach, wave action will regrade the surf zone and the crustacean infauna, and the sandpipers, will return.

Channel Sand Trap: The excavation itself would have no impact on wildlife. However, the additional quantities of sand deposited on the east beach will slightly increase impacts similar to those for the extension of the dredge pipe.

Offshore Sand Trap: This alternative will not affect the terrestrial wildlife in the project area because it is confined to the marine environment.

There are several indigenous species of marine mammals which may transit the area or forage in or near the kelp forest. There are no haul-out or nursery areas near the sand trap or disposal sites. Their diurnal routines will be affected to the extent that they will avoid the dredge equipment and the sediment plumes they generate. If some of these animals depend on the kelp forest or the disposal site for food, and if the possible adverse effects to the kelp forest manifest themselves, these animals will have to seek food elsewhere. Marine mammals are powerful swimmers with well developed senses and they have the ability to coexist with many human endeavors in the marine environment. Although the sand trap will have to be dredged annually, the impact to marine mammals is likely to be insignificant.

The nearest sea bird nesting site extends several miles westward along the shoreline from Point Santa Cruz. It is over a mile away from the sand trap and over two miles from the disposal site. Adverse effects to sea birds from this alternative will be insignificant and similar to those for marine mammals.

Fixed Jet Pump: The placement and operation of a sand passage device in the channel would not directly affect the wildlife. However, the placement of the device requires a temporary staging area on the west beach. A permanent pump

house, and some wiring and plumbing, will be fabricated on the west jetty. There would be a reduced impact to wildlife resident in the west jetty similar to the sand trap alternative.

Mobile Jet Pump: The placement and operation of a sand passage device on Seabright Beach would displace shore birds which feed in the receding surf from a small area of the beach. This displacement would last from the onset of excavation until the beach returns to its normal slope some time after the conclusion of the dredging season. This permanent adverse impact will last for several months each year. The magnitude of this impact is insignificant because the surf zone infauna which the shore birds dine on are generally plentiful, and these birds would forage on another section of the beach.

If there is a population of small animals residing in the west jetty, some of these animals may be displaced by construction activity. Once the pump house has been built and the piping placed, these creatures will probably repopulate the jetty. Because the pump is electric, the noise generated at the jetty will be insignificant. However, the mobile crane is diesel powered and will be used at least twice a day creating higher noise levels and producing exhaust fumes near the jetty. This will be a seasonal and intermittent impact that is not expected to have much effect on the jetty residents because these are expected to be those species which are tolerant of human activity.

5.4 Fish & Invertebrates

East Jetty Sealing: The underwater spaces in the east jetty that are filled with fluidized sand are not likely to contain any species of fish except by accident. Sealing the jetty would reduce the possibility of entrapping hapless fin fish in an inhospitable environment.

Clams and cockles which may have colonized the sand in the jetty would be displaced by the flushing operation. These species have stout shells or the ability to burrow vigorously; most individuals would be expected to survive. Some loss may occur from shell fracture or from burial too deep for the individual bivalve to return to its preferred depth in the sand.

The crustaceans of the open coast sand habitat are most likely to be in the interstitial sands. These creatures are equipped with hard shells, but these shells are not as strong as those of the bivalves. The flushing operation may kill greater numbers of these animals.

The encrusting and splash zone organisms, algae, limpets, barnacles mussels, and others, which have colonized the inner surfaces of the jetty will be permanently removed or killed in the flushing and sealing process. Since the interior of the jetty is of marginal value as habitat for most species, and since the jetty is very new relative to the rate of colonization by encrusting species, loss of this habitat is minimal.

Dredge Pipe Extension: Lengthening the dredge pipe and the subsequent deposition of sand further east will cause the crustaceans which inhabit the surf zone at that location to be displaced temporarily. These crustaceans migrate with the tides twice daily to maintain their favorite position in the sand and will have no trouble re-populating newly deposited sand.

Fin fishes do not occupy the surf zone any longer than it takes to swallow a sand crab, and therefore, will only be affected to the extent that their forage has moved relative to the discharge of dredged sediments.

Channel Sand Trap: The excavation will undoubtedly cause an increase of suspended solids in the water column resulting in an increase in turbidity. Water clarity would return to normal when the trap is completed. Since this excavation will take place in a zone of wave action and sand movement, few fish or invertebrates are likely to be affected.

Offshore Sand Trap: Resident, migrating, and foraging fishes will be displaced during the dredge and dump operation.

While a few fish may be killed by entrainment, the bivalves, crustaceans and worms will suffer the greatest losses. The excavated area will be devoid of benthic life until natural processes re-populate the sand trap. Because this dredging will be repeated annually, it is possible that the benthic fauna will not return completely to pre-dredge levels and a loss of biomass will result. Although the disposal site is expected to be dispersive, the dispersal rate is not known and the continued use of the site may prevent re-population by the benthic organisms and a permanently degraded habitat may result.

Fixed Jet Pump: The placement and operation of a sand passage device in the channel would entrain plankton and, possibly, an occasional hapless small fish or crustacean. The loss of fish or crabs would be negligible, but the effects on the plankton are unknown.

Mobile Jet Pump: Because the beach is a more stable environment than the harbor entrance, the biomass in the sand is likely to be higher. The placement and operation of a sand passage device in the intertidal zone would entrain benthos, plankton and, possibly, an occasional hapless small fish. The loss of fish will be negligible. Most of the invertebrates in the intertidal zone at the onset of excavation will be killed. The loss of crabs, clams, and worms would be insignificant because these species will repopulate the beach after wave action restores its normal slope. The effects on the plankton are unknown.

5.5 Water Quality

East Jetty Sealing: The sealant is expected to be non-toxic and confined to the interior and face of the jetty. Some slight increase in turbidity from

flushing and the operation of construction equipment may briefly degrade water quality in the project area.

Dredge Pipe Extension: Lengthening the dredge pipe and the subsequent deposition of sand further east will have no greater impact on water quality than the present system. If this alternative is effective, and dredging activity is partially curtailed, water quality over the long term may improve slightly.

Channel Sand Trap: The excavation will cause a slight increase of suspended solids in the water column resulting in an increase in turbidity. The movement of more sand to the east beach may contribute to the turbidity at the end of the discharge pipe. Water clarity would return to normal when the trap is completed.

Offshore Sand Trap: Some turbidity will result from the dredging of the sand trap. At the disposal site, the water will be much more turbid. Research has demonstrated that turbidity plumes from dredge operations disperse in less than one-half hour. The adverse effects to water quality will be temporary and will occur during each dredge event.

Fixed Jet Pump: The eductor nozzle is not expected to cause any turbidity in the channel. The subsequent deposition of more sand and seawater on the east beach will have a somewhat greater impact on water quality than the present system in proportion to the larger volume of dredged sand.

Mobile Jet Pump: The eductor nozzle is not expected to cause any turbidity, but the daily manipulation of the nozzle and the operation of the crawler-crane may cause brief increases in turbidity near the beach. Otherwise, impacts from this alternative are similar to those of the fixed jet pump.

5.6 Cultural Resources

All of the onshore areas of the project site were either intertidal or open water prior to the construction of the harbor. Cultural, archaeologic, or historic resources are not known to exist where construction or excavation activities would take place. However, a number of shipwrecks have been reported in the vicinity of the of the project area. If new areas or greater depths are proposed for dredging, then additional archival and on-site marine archaeological study will be undertaken to determine if marine historic properties are present and what management actions may be necessary.

5.7 Traffic & Transportation

East Jetty Sealing: The movement of cement trucks and other large pieces of construction equipment in and out of the project area will cause minor and temporary interruptions of traffic flow in the area.

Dredge Pipe Extension: This alternative would have the least impact as disruptions to traffic flow would occur only when sections of dredge pipe are moved on and off the beach. This impact would occur several times a year during the dredging season.

Channel Sand Trap: The excavation in the main channel may cause some minor and temporary delays to vessels entering and leaving the harbor.

Offshore Sand Trap: This alternative will not affect vehicular traffic or transportation in the project area because it is confined to the marine environment. However, the excavation in front of the harbor entrance may cause some minor and temporary delays to vessels entering and leaving the harbor.

Fixed Jet Pump: The installation of the eductor nozzle and peripheral equipment in and along the main channel may cause some minor and temporary delays to vessels entering and leaving the harbor. The movement of construction vehicles and other large pieces of equipment in and out of the project area will cause minor and temporary interruptions of vehicular traffic flow in the area.

Mobile Jet Pump: The installation of the eductor nozzle and peripheral equipment in and along the main channel may cause some minor and temporary delays to vessels entering and leaving the harbor. The movement of construction vehicles and other large pieces of equipment in and out of the project area will cause minor and temporary interruptions of vehicular traffic flow in the area. Since the crane and piping in excess of that required for the fixed jet pump are necessary, the impacts to land traffic may be greatest with this alternative.

5.8 Air Quality & Noise Conditions

East Jetty Sealing: There will be some increase in exhaust emissions in the project area from construction equipment and vehicles. Substantial increases in noise and dust will also take place. These impacts will be variable for the duration of construction, and limited to those times when construction equipment is in use.

Dredge Pipe Extension: Construction equipment is presently used to manipulate the dredge pipe on the beach. Therefore, the adverse impacts of lengthening the dredge pipe are likely to be insignificant. If this pipe is buried, any adverse effects will be prolonged for the amount of time necessary to cover the additional length of pipe.

Channel Sand Trap: There will be some slight increase in exhaust emissions in the project area from the dredge. This impact will be limited to the additional time the dredge is in use.

Offshore Sand Trap: A slight increase in exhaust emissions in the area will come from the dredge during the two to three weeks needed to excavate the sand trap. If this alternative significantly reduces the time that the *Seabright* must operate, a slight increase in air quality could result.

Fixed Jet Pump: There will be some increase in exhaust emissions in the project area from construction equipment and vehicles. Substantial increases in noise and dust will also take place. These impacts will be variable for the duration of construction, and limited to those times when construction equipment is in use.

Mobile Jet Pump: There will be some increase in exhaust emissions in the project area from construction equipment and vehicles. Substantial increases in noise and dust will also take place. These impacts will be variable for the duration of construction, and will continue at a reduced level after construction, during the operation of the system.

5.9 Recreation

East Jetty Sealing: The use of several thousand square feet of the beach for recreational activities will be lost during the construction period. As the beach is not very large, this impact is substantial, but limited to the time it will take to seal the jetty and regrade the beach.

Dredge Pipe Extension: Recreation is continually being affected by the manipulation of the dredge pipe on the beach during the dredging season. Normally, this is done during the winter months when beach use is low. Therefore, the adverse impacts of lengthening the dredge pipe are likely to be insignificant.

Channel Sand Trap: Recreational boaters using the main channel may experience some temporary inconvenience during excavation.

Offshore Sand Trap: Fishing and scuba diving may be temporarily less enjoyable during the few weeks of dredge operation due to the displacement of fishes and increased turbidity.

Fixed Jet Pump: Recreational boaters using the main channel may experience some temporary inconvenience during placement of the eductor nozzle and accessory piping. The use of several thousand square feet of the beach for recreational activities will be lost during the construction period. Because the beach is not very large, this impact is substantial, but limited to the time it will take to place piping and cables and to construct the support building. Although the pump is electric, operation of the system will generate some noise. This noise

will probably not be audible except close to the pump house and may be muffled by ambient conditions.

Mobile Jet Pump: Recreational boaters using the main channel may experience some temporary inconvenience during placement of the accessory piping. The use of several thousand square feet of the beach for recreational activities will be lost during the construction period. Because the beach is not very large, this impact is substantial, but limited to the time it will take to place piping and cables and to construct the pump house. Once the pump house has been built and the piping placed, the noise generated at the jetty by the electric pump should be insignificant. However, the crane is diesel powered and will be used at least twice a day creating higher noise levels and producing exhaust fumes near the jetty. This seasonal and intermittent impact will continue annually while the crane is in use.

5.10 Aesthetics

East Jetty Sealing: Because the grout material will be confined to the interior and face of the jetty, and because the beach will be regraded to its usual slope, the aesthetic appeal of the area will only suffer temporarily.

Dredge Pipe Extension: The aesthetic appeal of the area is impaired by the presence and manipulation of the dredge pipe on the beach during the dredging season. Normally, this is done during the winter months when beach use is low. Therefore, the adverse impacts of lengthening the dredge pipe are likely to be insignificant.

Channel Sand Trap: The increase of turbidity during the excavation would temporarily degrade the appearance of the ocean in the project area.

Offshore Sand Trap: The beach and harbor area will suffer a minor, temporary, and annual impact to aesthetic appeal while the dredge is operating and the water is cloudy.

Fixed Jet Pump: The deposition of additional sand upon the beach will have a slightly more adverse effect than the present dredging operation. However, the construction of permanent support structures and building for this alternative will have some impact. This permanent impact will range from slight to moderate and depend largely on the design and placement of these structures. This impact is reduced to the extent that cabling and piping are located under water or are buried.

Mobile Jet Pump: The deposition of additional sand upon the beach will have a slightly more adverse affect than the present dredging operation. However, the construction of a permanent building for this alternative will have

some impact. This permanent impact will range from slight to moderate and depend largely on the design and placement of the pump house, cabling, and wiring. The presence of the crane, piping and the excavation near the jetty will adversely affect the visual appearance of the west beach during the dredging season.

5.11 Socio-Economic Impacts

At the start of this study, a public workshop was held on 16 July 1991 in Santa Cruz. After some preliminary solutions were identified, a questionnaire was prepared in December of 1991. This document has been distributed to some businesses, user groups, and individuals who either use the harbor or have some interest in it. The information from the survey will be used to assess the impacts of the alternatives on the citizens of Santa Cruz and to refine this environmental assessment.

5.12 Threatened & Endangered Species

There are 22 species of birds and mammals and plants that are threatened or endangered in the Monterey Bay area. At this time, there are no federal or state protected wildlife species residing in the project area. Individuals of several of these species may be seen in, or transit the vicinity, but none depend on the area for subsistence, shelter, or reproduction.

At this time, there are no federal or state protected plant species in the project area. Because these plants have not been observed does not mean they never occur in the area. Environmental conditions and competition in plant communities vary seasonally. The project area should be monitored periodically to verify the presence or absence of sensitive plant species.

5.13 Coastal Zone Management Act Consistency Determination

Work under the construction alternatives would directly affect the coastal zone of the State of California. Under Section 307(c) of the Coastal Zone Management Act, the proposed construction must be consistent, to the maximum extent practicable, with the State's approved management program, i.e. the California Coastal Plan. Following plan selection in the feasibility phase of this study, a consistency determination will be submitted to the California Coastal Commission.

5.14 Other Impacts

The construction of the harbor radically altered the downcoast transport of sand. Any permanent modification of the harbor has the potential to affect littoral transport as well. To the extent that sand movement is maintained in

the system, resolution of the shoaling problems in the harbor may have a beneficial impact on the downcoast beaches.

There are, however, some possible adverse effects. Sealing the face of the east jetty may exacerbate phenomena such as scouring of the beach adjacent to the sealed face, wave runup on the jetty, and overtopping into the channel.

6.0 COORDINATION

The Fish And Wildlife Coordination Act of 1934 requires the U. S. Fish and Wildlife Service (FWS) to review and make mitigation recommendations for any federal water project which may have adverse impacts upon the environment. The FWS was contracted to provide a Planning Aid Letter in September 1991. This letter was received in January 1992 (Attachment 1). Information and recommendations therein were used in the preparation of this document.

The consideration of the offshore sand trap alternative is a recent development of which the USFWS is not aware. However, dredging is at the core of some of the alternatives and the USFWS has addressed the effects of dredging and disposal on the marine environment in this Planning Aid Letter.

This Environmental Assessment will be provided to the Environmental Protection Agency, United States Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Game, California Regional Water Quality Control Board, California Department of Parks and Recreation, California Coastal Commission, State Historical Preservation Officer, State Lands Commission, various City and County of Santa Cruz agencies, various private environmental groups and others for review and comment in the feasibility phase of this study.

7.0 CONCLUSIONS

For the offshore sand trap, an environmental impact statement will be required for the borrow area and for the disposal site. Concern has been expressed over the location of the boundaries of the Monterey Bay National Marine Sanctuary and the possible encroachment of this alternative into federally protected environments. The Draft EIS/Management plan for this sanctuary excludes the harbors of Monterey, Moss Landing, and Santa Cruz. However, the precise boundaries of the harbors are not defined in this document.

On February 12, 1992, the Corps had a telephone consultation with the NOAA Marine and Estuarine Management Division in Washington, DC. From this, we learned that although the mean high water line has been established as the landward boundary of the sanctuary, those areas landward of the established Collision Regulations lines are excluded from the sanctuary. On NOAA Chart 18685, the line (Collregs 80.1255) for Santa Cruz Harbor is from Point Santa Cruz to the tip of the west jetty of the small craft harbor. This means that

most of the sand trap and all of the disposal site are inside the sanctuary. Based on this limited reconnaissance, we anticipate NOAA will refuse a permit for the disposal of dredged material inside the sanctuary.

The remaining alternatives presented in this study are not likely to have any permanent adverse impact on the environment. There will be some significant temporary impacts. Retail business and recreation will be subject to increased levels of dust and noise and to the disruptions to traffic from the influx of construction vehicles. Portions of the beach will be closed, curtailing recreational activities to some extent.

Any change in the configuration of the harbor or enhancement of maintenance dredging which improves the passage of sand downcoast or reduces the number of days the port district must dredge, may be viewed as beneficial effects.

Although the harbor has interrupted the littoral transport of sand to downcoast beaches, the sand trapped by the west jetty has nourished Seabright Beach providing some protection to the cliffs from wave action. The sand is sufficiently stable in some places that vegetation has become established and small sand dune communities are developing. The deposition of dredged sand onto the state beach has had a similar benefit, but this beach does not show the same dune community development.

The possibility exists that a combination of alternatives may be used to ease the problems in Santa Cruz Harbor. This combined solution is not yet known, therefore, the environmental impacts remain unknown. Since none of the individual alternatives is likely to have any permanent adverse impact, it is probable that a combination approach will have only those temporary impacts expected from the selected alternatives.

REFERENCES

Anonymous. 1991.
City of Santa Cruz General Plan 2005. Santa Cruz, CA.

Crampton, Beecher. 1974.
Grasses in California. University of California Press, Berkeley, CA.

Gearhart, Robert L., et al. 1990.
California, Oregon, and Washington Archaeological Resource Study. U. S. Department of the Interior, Minerals Management Service, Espey, Huston and Associates Inc. Austin, TX

Griggs, Gary & Lauret Savoy, editors. 1985
Living with the California Coast. Duke University Press, Durham, NC 27708.

Kyle, Douglas E. Editor. 1990.
Historic Spots in California, Fourth Edition. Stanford University Press, Stanford, CA.

Levy, Richard. 1978.
Costanoan in Handbook of North American Indians, Volume 8, California, Robert F. Heizer editor. Smithsonian Institution, Washington, DC.

Moratto, Michael J. 1984.
California Archaeology. Academic Press. Orlando, FL.

Moore, Jon T. 1972.
A Case History of Santa Cruz Harbor. Hydraulic Engineering Laboratory, College of Engineering, University of California, Berkeley, CA.

Niehaus, Theodore F. 1976.
A Field Guide to Pacific States Wild Flowers. Houghton Mifflin Company, Boston, MA 02108.

National Ocean Service. 1990.
Draft Environmental Impact Statement and Management Plan for the Monterey Bay National Marine Sanctuary. National Oceanic and Atmospheric Administration, Washington, DC 20235.

Nixon, Scott W., Candace A. Oviat, & Sharon L. Northby. 1973.
Ecology of Small Boat Marinas. Marine Technical Report Series Number 5. University of Rhode Island, Kingston, RI

O'Connor, Joseph M. 1991.
Evaluation of Turbidity and Turbidity-Related Effects on the Biota of the San Francisco Bay-Delta Estuary. San Francicso Bay-Delta Aquatic Habitat Institute. Richmond CA 94804.

Reinstedt, Randall A. 1975.
Shipwrecks and Sea Monsters of the Central California Coast. Ghost Town Publications, Carmel CA 93921.

Rickets, Edward F., Jack Calvin & Joel W. Hedgepeth. 1985.
Between Pacific Tides. Stanford University Press. Stanford, CA.

Silberstein, Mark. 1981.
SCUBA Reconnaissance of the Proposed Santa Cruz Harbor Dredge Disposal Sites. Unpublished.

Smith, Gilbert M. 1969
Marine Algae of the Monterey Peninsula. Stanford University Press, Stanford, CA.

Squire, James L. Jr. & Susan E. Smith. 1977.
Angler's Guide to the United States Pacific Coast. DOC, NOAA, National Marine Fisheries Service. Seattle, WA.

U. S. Army Corps of Engineers. 1975.
Final Environmental Statement Maintenance Dredging (FY 1975-1976 Santa Cruz Harbor, Santa Cruz, California. San Francisco District, San Francisco, CA.

U. S. Army Corps of Engineers. 1976.
Environmental Assessment Experimental Sand Bypassing Plant, Santa Cruz Harbor, Santa Cruz, California. San Francisco District, San Francisco, CA.

U. S. Army Corps of Engineers. 1977.
Environmental Assessment Maintenance Dredging, Santa Cruz Harbor, Santa Cruz, California. San Francisco District, San Francisco, CA.

U. S. Army Corps of Engineers. 1985.
Environmental Assessment Santa Cruz Harbor - Maintenance Sealing of the East Jetty Project Santa Cruz County, California. San Francisco District, San Francisco, CA.

U.S. Army Corps of Engineers. 1988.
Sphere of Influence for the Santa Cruz Port District. San Francisco District, San Francisco, CA

United States Department of the Interior

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January 15, 1991

SHOULD BE 1992 jal

William C. Angeloni, Chief
Planning/Engineering Division
San Francisco District, Corps of Engineers
211 Main Street
San Francisco, CA 94105-1905

Re: Planning Aid for Santa Cruz Harbor Shoaling Reconnaissance Study

Dear Mr. Angeloni:

This planning aid letter provides our preliminary assessment of impacts to fish and wildlife resources associated with the Santa Cruz Harbor Shoaling Project at Santa Cruz, California. The intent of this letter is to assist with the preparation of a draft Environmental Assessment for the referenced study. This planning aid letter has been prepared in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.W.C. et seq.). This letter is for technical assistance purposes only and does not constitute our reporting requirements under Section 2(b) of the Act.

The Service's findings and comments related to the proposed construction alternatives are based on the project sketches and descriptions furnished to us in October, 1991 by the Corps. Additional information was supplied to our agency during a site visit on 14 December 1991. There we met with personnel from the Corps (Jeff Cole) and the Santa Cruz Port District (Brian Foss, Director; Stephen Scheiblauer, Harbormaster; Robert Byington).

With the release of a Draft Environmental Impact Statement and Management Plan (DEIS/MP) in August, 1990, the National Oceanic and Atmospheric Administration (NOAA) proposed to designate Monterey Bay, in which the Santa Cruz Harbor is located, as a National Marine Sanctuary (U.S. Dept. Commerce, 1990). Further information for this letter was obtained from Part II, Section 2 of the DEIS/MP, which provides a relatively up-to-date description of the area's marine ecosystem resources. Other sources are cited in the reference section appended to this letter.

PROJECT LOCATION

The site of the proposed project is the Santa Cruz Harbor which is located in the City of Santa Cruz on the central California coast at the northern end of Monterey Bay (Figure 1).

PROJECT DESCRIPTION

For years the Port of Santa Cruz has experienced a problem with harbor entrance shoaling. Navigation channels in Santa Cruz Harbor require periodic dredging to maintain adequate depth for marine vessels. Currently the dredging is performed with a barge-mounted suction dredge. A slurry of dredged material and seawater is pumped from the barge by pipeline to the disposal site on the beach. The current dredging program ("No Action Alternative") dredges and disposes material five months per year during the winter months. Your request to the Service dealing with the subject project briefly outlined five proposed alternatives designed to minimize the shoaling which occurs at the opening of the Santa Cruz Harbor during the winter months especially during adverse weather conditions and/or increase the efficiency of current dredging operations dealing with the same. The primary object of the project, according to your letter, is to keep the harbor channel open for safe navigation at the least cost.

DESCRIPTION OF EXISTING FISH AND WILDLIFE: HABITAT & RESOURCES

GEOLOGY

As part of the Monterey Bay region, the Santa Cruz Harbor area is located within the California Coast Ranges province. It is positioned on a major structural unit of the earth's continental crust called the Salinian Block. About 20 million years ago, this block was thrust northward from the southern Sierra-Nevada Mountain Range on the Pacific tectonic plate by movement along the San Andreas Fault. Faults in area lie primarily within two major, essentially northwest-southeast-trending fault zones: the Palo Colorado-San Gregario and the Monterey Bay fault zones. Movement in this active Monterey Bay Fault Zone caused the recent (17 October 1989) San Francisco Bay area earthquake, with its epicenter of 7.1 on the Richter Scale near Santa Cruz.

The most pronounced geological feature of Monterey Bay is the Monterey Submarine Canyon. The main canyon begins in 18 m of water about 100 m offshore from Moss Landing, 15 miles south of Santa Cruz. There are two main branches of the Monterey Canyon: Soquel Canyon to the north (which is most proximate to the Santa Cruz Harbor) and Carmel Canyon to the south. An additional canyon, Ascension, indents the shelf off of Ano Nuevo.

The substrate of the bay is variable (Martin and Emery, 1967). The surface sediment types tend to follow the seafloor contours (Figure 2). Nearshore the sediments are sand and fine sand, offshore they are sand and mud. In both areas, the sediments overlie beds of sandstone, siltstone, and conglomerate. (DEIS/MP p. 26-30)

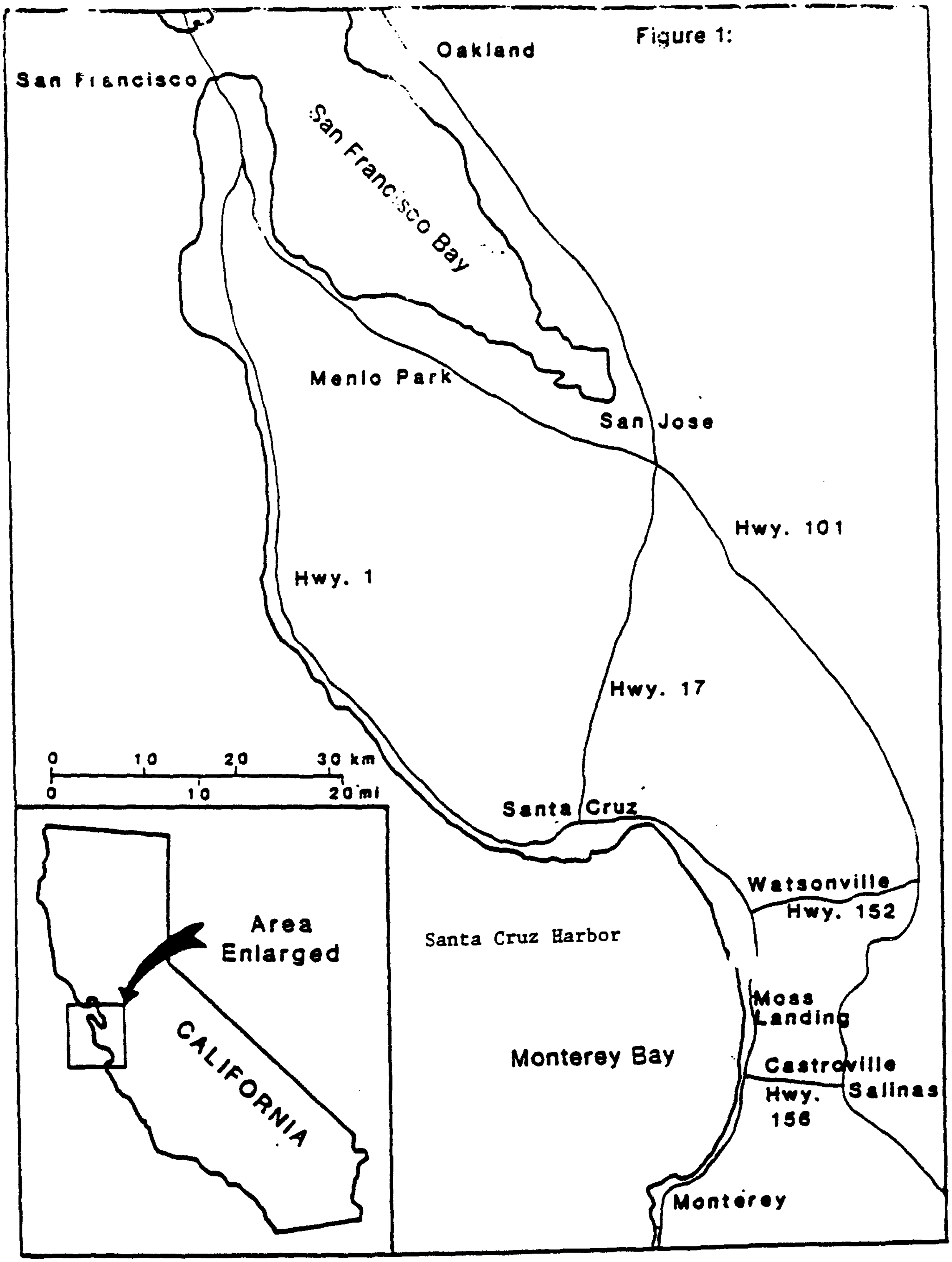


Figure 1. Santa Cruz Harbor Shoaling Project Site

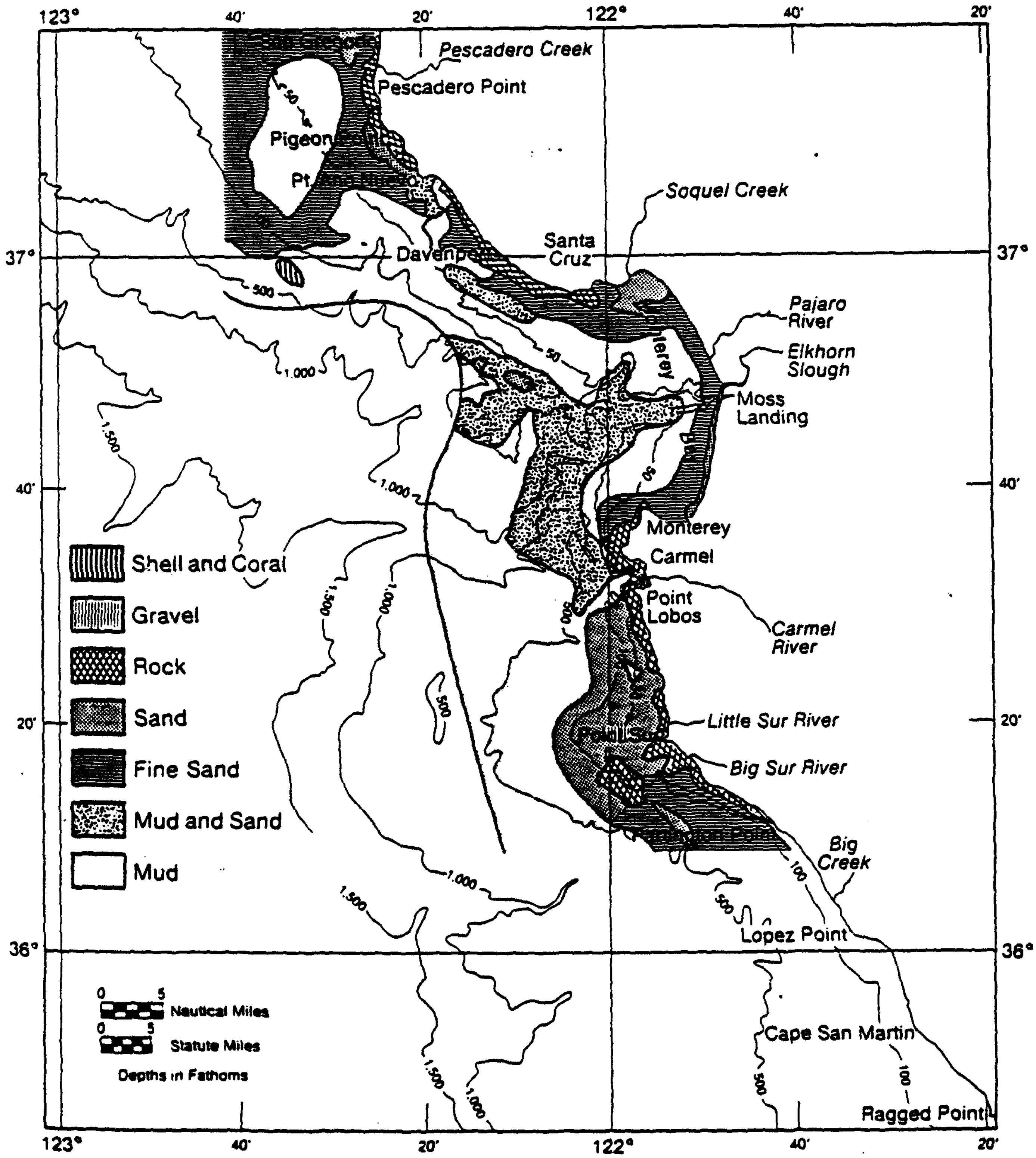


Figure 2 Monterey Bay Area Sediment Types (NOAA, 1982).

Nearshore the sediments are sand and fine sand, offshore they are sand and mud. In both areas, the sediments overlie beds of sandstone, siltstone, and conglomerate. (DEIS/MP p. 26-30)

The Santa Cruz Harbor lies on a coastline delineated by a narrow continental shelf. It is surrounded by a variety of coastal types: granite boulder- strewn headlands at the southern part of the bay, white dunes and beaches of the central bayshore, and sand bluffs, flat-topped mudstone terraces and sandy beaches of the bay's northern coastline.

METEOROLOGY

As to area's meteorology, the seasons are not well marked. The area has a moderate maritime climate with the general pattern of wet winters and relatively dry summers. January and February are usually the wettest months, while July and August are virtually without rainfall (Gordon, 1977). The amount of rainfall varies markedly not only year to year but also on both sides of the bay. Monterey averages about 15 inches (38 cm) annually; Santa Cruz averages about 28 inches (69 cm).

From March through October the prevailing winds are from the northwest. Winds in the winter season are variable, often from the west or southwest. The strongest winds occur in May (averaging 14 knots) and the weakest between November and January (averaging 3 knots) (Breaker and Broenkow, 1989). The cool water of the California Current flows south along the coast from March through October; however, between November and February this current moves offshore and is replaced with the warmer northward flowing waters of the Davidson Current. The net effect of these alternating currents is that the Monterey Bay climate is characterized by both northern temperate and southern sub-tropical features. (DEIS/MP p. 30-1)

The height of the waves in the bay around the Santa Cruz Harbor vary with the seasons. Under more stable summer conditions, the waves are able to build broad, gently-sloping beaches. Winter conditions produce higher waves that transport sand to the offshore zone and erode beaches (Gordon, 1977). Further detail with respect to wave action and currents is summarized in the DEIS/MS (pp. 31-36).

HABITAT

Biogeographically, the Monterey Bay is in the Oregonian province subdivision of the Eastern Pacific Boreal Region, which is characterized by a rich cold- temperate flora and fauna (Briggs, 1979). At the same time, however, it supports a number of warm water invertebrate species characteristic of the California province to the south. This overlap and co-occurrence of cold and warm water species contributes to the diversity of the living natural resources in the region. The nutrient-rich waters of the bay support extensive plankton, algae, invertebrate, fish, seabird, and marine mammal populations.

The biodiversity of the bay is directly related to the diversity of habitats found in the bay, which include: submarine canyon habitat; nearshore

sublittoral habitat; rocky intertidal habitat; sandy beach intertidal habitat; and kelp forest habitat (Figure 3). Information about the submarine canyon habitats can be obtain from the DEIR/MP (pp. 37-39).

Nearshore Littoral

The nearshore sublittoral habitat is found in the nearshore waters of the continental shelf in depths from just beyond the surf to 200 m depth. The nearshore benthic habitat is characterized by a soft bottom composed of unconsolidated sand and mud sediments. This is the most extensive bottom habitat in Monterey Bay and is found in the area fronting the Santa Cruz Harbor. The food chain is based on planktonic productivity supported by upwelling of nutrient-rich waters from the Monterey Canyon. Two major groups of invertebrates are found in this habitat: 1) the infauna, which live buried within the sediment, comprise about 90 percent of all the bottom-dwelling organisms; and, 2) the epifauna, which live on or crawl or move over the bottom. Both groups are patchily distributed. Many benthic organisms have a pelagic phase in their life histories (Nybakken, 1982). Pelagic organisms found in this habitat include phytoplankton and zooplankton, squid and octopus, and most of the important commercial fish (salmon, albacore, mackerel and anchovy). Marine birds and California sea lions feed throughout the habitat....." (DEIS/MP, p. 39-40). This habitat also includes commercially important fish such as the northern anchovy, Pacific herring, jack mackerel, Pacific sardine, king salmon, and juvenile sablefish.

Rocky Intertidal

The rocky intertidal habitat is found on rocky substrate between the lowest tidal level and the highest tidal level. Organisms living in this area must be able to withstand periodic desiccation, high temperature and light, low salinities, and strong wave action (Nybakken, 1982). (DEIS/MP p. 40-1) To some extent, the rock jetties that extend out into the bay at the mouth of the Santa Cruz Harbor afford this type of habitat.

Sandy Intertidal

Sandy beaches are the dominant intertidal habitat in Monterey Bay [including the area of Santa Cruz Harbor]. The environmental conditions that exist in this habitat between high and low water require almost all organisms to bury themselves in the sand. This is a very dynamic habitat with constantly shifting sands caused by wave action and the longshore transport of sand. The overall productivity of this habitat is lower than that for rocky intertidal habitats (Nybakken, 1982).

Benthic diatoms are the only marine algae that may be present. Oakden and Nybakken (1977) found 29 genera or species of animals in transects taken over the course of a year. Polychaete worms, bivalve molluscs, and crustaceans were the predominant invertebrates found. Sand dollars and gastropod molluscs are also found here (Wilson, 1986). The only fish that are common are those that use sandy beaches for spawning, e.g., the surf smelt and grunion. (DEIS/MP DEIR, p. 41-2) Other species that forage near sand flats include surf perch, striped bass, jacksmelt, starry flounder, sand sole, and sand dab.

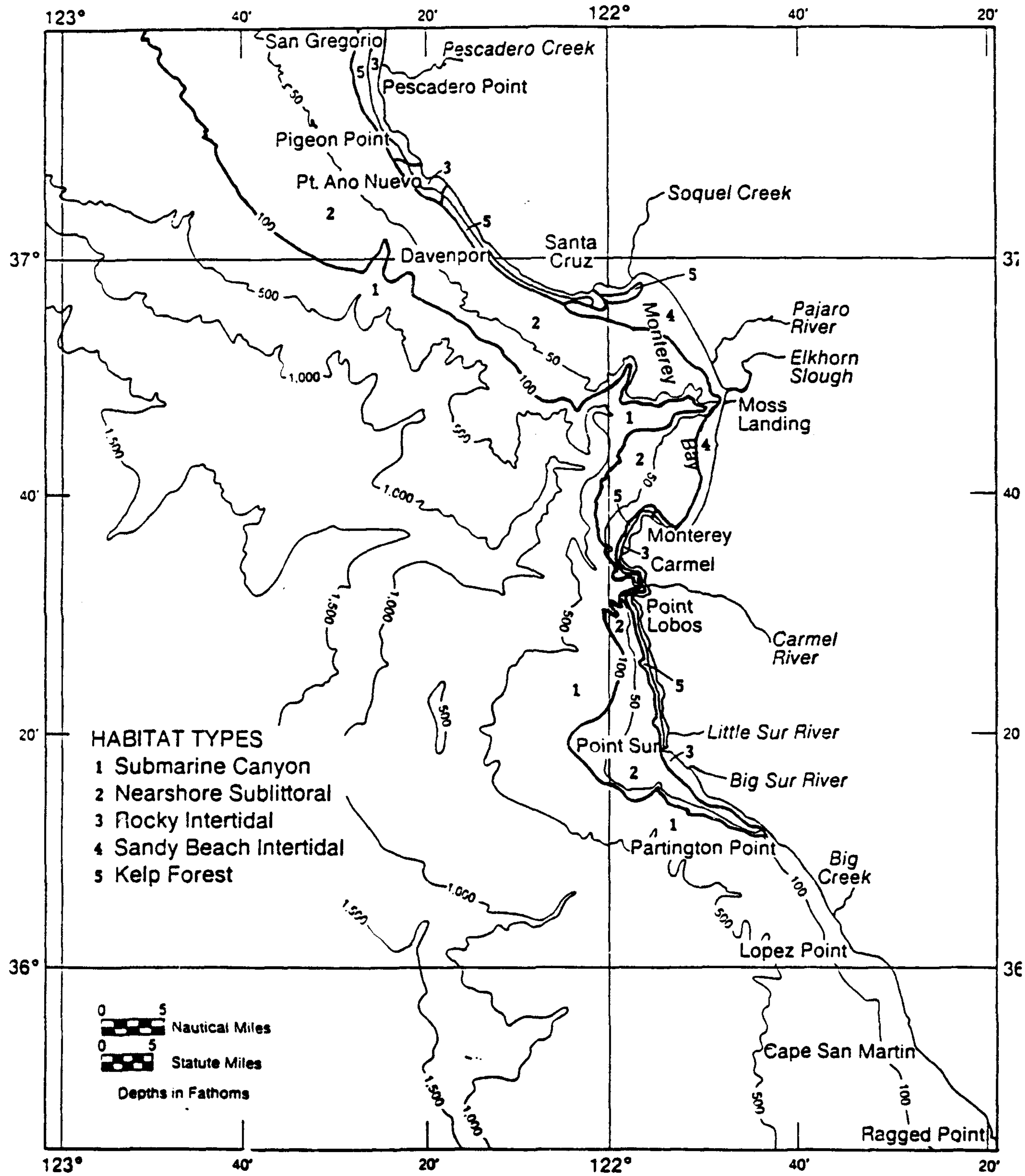


Figure 3 Types of Habitat within Monterey Bay Area (NOAA, 1982).

The Monterey Bay also supports kelp forest habitat. Some of this type of habitat is found in the vicinity of the Santa Cruz Harbor. This large brown algae attaches to rocky substrate and grows in water depths from about 2 m to 20 m. The floating portions of these plants form dense canopies on the water surface. Kelp forests provide critical habitat for encrusting animals such as sponges, bryozoans, and tunicates, as well as for juvenile fish, molluscs such as abalone, algae, and for other grazing and detritus-feeding invertebrates, such as isopods and sea urchins. Predators, such as sea stars, are also active there. Fish associated with kelp beds include greenling, lingcod, bocaccio, and many species of surf perches and rockfish. Sea otters and harbor seals are commonly associated with kelp forests in the area.

BIOLOGICAL RESOURCES

We have briefly described the principal habitat types found in the local vicinity of the Santa Cruz Harbor area: nearshore sublittoral, rocky intertidal, sandy intertidal and kelp forest. It is these habitats on which the current dredging operations, as well as the modifications being considered in the reconnaissance study, may have varying degrees of impact. The biological fauna of these habitats include plankton, algae, invertebrates, fish, seabirds and marine mammals.

PLANKTON

The plankton species present in the Monterey Bay area are primarily characteristic of the cold-water regime, but also include a few warm-water species (Holton et al., 1977; Riznyk, 1977, Garrison, 1979). Upwelling from the canyon carries some deep water species close to shore.

Diatoms are the primary component of the phytoplankton. The spring to late summer period of upwelling with its nutrient-rich waters causes a seasonal variation in the standing stock of phytoplankton. The highest primary productivity is associated with the upwelling period; the lowest during late fall through winter when the warmer Davidson Current replaces the California Current and upwelling ceases. Dinoflagellate blooms occur in the fall in these warmer waters. Satellite imagery indicates that phytoplankton concentrations are frequently higher in the Santa Cruz region of the bay (Hauschildt, 1985).

Unlike phytoplankton, which are limited to the euphotic zone (approximately the upper 100 m), zooplankton occur at all depths and are able to migrate vertically up to several hundred meters. The phytoplankton are fed upon by a variety of zooplankton such as ciliates, copepods, euphausiids, and pelagic tunicates. Zooplankton are in turn an important food source for fish and other organisms. Dense concentrations of euphausiids occur in the surface waters and in deeper layers from 100 to 400 m from April to November (Barham, 1956; Schoenherr, 1988). These swarms serve as food for a variety of adult fishes, whales and sea birds (Harvey, 1979); Schoenherr, 1988), and for juvenile fishes which prey on euphausiid eggs and larvae (NOAA Rockfish Recruitment Cruise Reports, 1986- 1988). Dense swarms of gelatinous pelagic tunicates also occur periodically from early spring to mid-fall (Barham, 1956).

ALGAE

Large marine algae, or seaweeds, are diverse and abundant in the Monterey Bay area. The extent of this diversity is shown by the presence of over 450 of the 669 species of algae described fo~ California (Abbot and Hollenberg, 1976). The area has the largest marine flora of the temperate northern hemisphere, with numerous endemic species and the only population of one large understory kelp (Eisenia arborea) between southern California and Canada (Foster et al., 1988).

The seaweeds of the Monterey Bay area are composed of three main phyla: red algae (69 percent of all species), brown algae (20 percent), and green algae (10 percent). They occur primarily in areas of rocky substrate and only rarely in water deeper than 40 m (Abbott and Hollenberg, 1976). The most extensive algal communities are dominated by forests of giant kelp (Macrocysti pyrifera) and bull kelp (Nereocystis leutkeana). Bull kelp rejuvenates itself annually; giant kelp is generally perennial, growing all year. The Santa Cruz County coast between Terrace Point and Point Ano Nuevo has changed from almost total dominance of giant kelp in 1911 to an increase in the number of bull kelp stand (Yellin et al., 1977). Although sea otters may produce further changes, the primary factors affecting these kelp forests appear to be storms and substrate composition (reviewed in Foster and Schiel, 1985).

INVERTEBRATE

The rich invertebrate community provides an important food source for marine mammals, sea and shore birds, and fish found in Monterey Bay. The distribution, species composition, and abundance of this fauna in Monterey Bay are determined by many factors. The submarine geology and the types of rocky substrate or unconsolidated sediments, the submarine canyon and associated upwelling, the offshore currents and circulation patterns, the kelp forests, and the presence of mammal predators all influence the niches occupied by the various species (Table 1).

The nearshore subtidal invertebrate fauna of the shallow offshore waters are found in a far greater number of species than are the sandy intertidal fauna. However less is known about these subtidal species than is known about the intertidal. Nearshore benthic invertebrates include polychaetes and other worms; molluscs such as snails and bivalves; ostracods, amphipods, isopods, and other crustaceans; and starfish. The dominant invertebrate groups in the shallow subtidal waters are polychaetes, molluscs, and crustaceans. Crustaceans are dominant in shallow areas; polychaetes are dominant in deeper waters. The rocky intertidal habitat supports the widest array of invertebrate species (Ricketts et al., 1985; Smith and Carlson, 1975; Morris et al., 1980). Characteristic species include the periwinkles, isopods, barnacles, limpets, sea snails, crabs, chitons, mussels, sea starts, and anemones. Squid, octopus, jellyfish, salps, heteropods, and euphausiids are some of the macro-invertebrates found in the pelagic environment. Numerous larval invertebrates are also found there during their planktonic stages of development. The rich invertebrate community provides an important food source for marine mammals, sea and shore birds, and fish found in Monterey

Table 1 Representative Invertebrates Associated with the Diverse Habitats of the Monterey Bay Area (J. Nybakken, pers. comm., 1989).

Habitat	Representative Invertebrates	Classification	Common Name
Submarine Canyon	hexactinellid	Porifera	glass sponge
	gorgonians	Cnidaria	soft coral
	euphausiids	*Euphausia pacifica*	krill
	bivalve	Calyptogena	clam
	crinoids	Echinodermata	sea lily
Nearshore	polychaetes	*Aricidea* sp.	bristle-worms
sublittoral	bivalves	*Macoma* sp.	burrowing clam
	snails	*Olivella biplicate*	olive snail
	crabs	*Blepharipoda occidentalis*	spiny sand crab
	mysids	*Acanthomysis davisi*	opossum shrimp
	tunicates	*Doliolum tritonis*	salps
Sandy Intertidal	bivalves	*Tivela stultorum*	pismo clam
	crabs	*Emerita analoga*	mole crab
	amphipods	*Orchestoidea* spp.	sand hoppers
	sea urchins	*Dendraster excentricus*	sand dollar
	snails	*Olivella columellaris*	olive snail
Kelp Beds	gastropods	Haliotidae	abalone
	bryozoans	Membranipora	encrusting bryozoan
	tunicates	Ascidiacea	sea squirt
	gastropods	*Acmaea* spp.	limpet
	sea urchins	*Strongylocentrotus purpuratus*	purple sea urchin
	gastropods	Tegula	turban snails
Rocky Intertidal	sea snails	*Littorina* spp.	periwinkles
	sea stars	*Asteroidea* spp.	starfish
	barnacles	*Balanus* spp.	acorn barnacles
	bivalves	*Mytilus* spp.	mussels
	sea anemones	*Anthopleura elegantissima*	aggregate sea anemone
	sea snails	*Tegula funebralis*	Black Turban snail

Bay. In addition, many invertebrates, such as squid, spot prawn, Dungeness crab, abalone, and pismo clam, are harvested by commercial and recreational fishermen (DEIS/MP, p 48-50).

FISHES

The same environmental factors that determine the distribution, abundance and species composition of the other living resources of the area also affect the fish communities. In addition to the presence of the submarine canyon and the upwelling of nutrients, kelp beds provide shelter and food for juvenile and spawning areas for many species of fish.

The diverse habitats of the area each have their own characteristic assemblage of fish (Table 2). Fish of the nearshore subtidal habitats exhibit the greatest diversity. This habitat includes many commercially important fish such as the pelagic schooling species (northern anchovy, Pacific herring, jack mackerel, sardine), the large predators (king salmon, sablefish, sharks), and some demersal species (English and petrale sole). Many important species of rockfish are found over rocky reefs.

The rocky intertidal habitat is characterized by a rather small and specialized group of fish adapted for life in tide pools and wash areas. The most representative species are the monkey-face eel, rock eel, dwarf surfperch, juvenile cabezon, sculpins, and blennies (California Department of Fish and Game, 1979).

Sandy intertidal areas are used by small pelagic species (grunion and smelt) that use the beaches of the inner bay for spawning. Other species that forage near sand flats include the surf perch, striped bass, jack smelt, sand sole, sanddab, and starry flounder.

The kelp canopy, stipes, and holdfasts increase the available habitat for pelagic and demersal species and offer protection to juvenile finfish. Greenling, lingcod, and numerous species of rockfish are the dominant fishes.

SEABIRDS

The Monterey Bay area historically has been recognized as a uniquely important region of seabird occurrence (Loomis, 1895, 1896; Beck, 1910). Several environmental features are responsible for the diverse assemblage of birds in the area:

* the bay is located on the Pacific Flyway, allowing the birds a place to stopover during both north and south migrations between southern wintering grounds and northern breeding sites.

* the upwelling of nutrient-rich waters over the submarine canyon support highly productive food webs which provide abundant seabird prey.

Table 2 Major Species of Fish Caught from Private or Rental Boats, Beaches, Piers and Jetties (Marine Recreational Fisheries Statistics Survey, 1987).

Private or Rental Boats

Blue rockfish
Pacific sanddab
Rockfishes (general)
Longfin sanddab
Lingcod
Gopher rockfish
Albacore tuna
Yellowtail rockfish
Chilipepper
Brown rockfish

Beaches

Barred surfperch
Staghorn sculpin
Flatfishes
Surfperches
Calico surfperch
Senorita
Silver surfperch
Walleye surfperch
Black perch
Rockfishes (general)

Piers

Staghorn sculpin
Jacksmelt
White croaker
Pile perch
White seaperch
Surfperches
Lingcod
Chinook salmon
Rainbow trout
Kelp rockfish

Jetties

Surfperches
Rockfishes (general)
Staghorn sculpin
Northern sculpin
Pile perch
Rainbow seaperch
Senorita
Starry flounder
Cabezon
White croaker

* plumes of upwelling in the outer shelf regions also act to concentrate prey near the surface in "fronts" at the plume edges (Briggs et al., 1983 1987a, b; Briggs and Chu, 1986, 1987).

* the availability of food in a bay protected on three sides allows birds that normally feed far offshore to seek shelter during storms.

* the diversity of habitat types along the shore increases the variety of bird species which utilize the bay area.

Ninety-four seabird species are know to occur in the Monterey Bay region, of which about thirty species predominate in their preferred seasons and habitats (Briggs and Chu, 1987). Table 3 lists some important seabirds and their seasonal status. Thirteen species are resident breeders or former breeders within the region. Common breeding species include Brandt's comorants, western gulls, pigeon guillemots, and common murres (Dohl, 1983). The location of important seabird colonies are shown in Figure 4.

The majority of seabirds occur here as non-breeding residents/visitors and spring/autumn migrants. The area is important habitat for visiting autumn and winter populations of ashy storm-petrels, California brown pelicans, sooty and short-tailed shear-waters, western grebes, common murres, marbled murrelets, Cassin's and rhinoceros auklets, surf scoters, and several species of gulls. Spring and fall migrant species include phalaropes, Pacific loons, common and arctic terns, and pomarine and parasitic jaegers. Ashy storm-petrel populations currently number less than 10,000 birds. About 85% of them breed on the Farallon Islands. Almost all of them come to Monterey Bay to feed over the submarine canyon during the summer and fall (Roberson, 1985).

Additional facts about several species further indicate the importance of the Monterey Bay area to seabirds. The southernmost relic population of the severely threatened marbled murrelet occupies several isolated sites in the Santa Cruz Mountains. Ano Nuevo Island was recently colonized by rhinoceros auklets (their southernmost confirmed nesting site) and contains the largest colony of western gulls in the region (Lewis & Tyler, 1987). The seacliffs of Santa Cruz and Monterey counties support more nestling pigeon guillemots than the Farallon Islands, which has the largest single colony in California.

During spring migration, large numbers of shorebirds gather on the beaches. Common migrant shorebirds include sandpipers, turnstones, plovers, sanderlings, willets, and godwits. Many of these species also winter in the area in large numbers. Located approximately 12 miles south of Santa Cruz Harbor, Elkhorn Slough seasonally harbors over 30,000 shorebirds during migrations (Stenzel et al., MS). Nearly a fifth of California's breeding population of snowy plovers nest on the beaches in the area and this species is especially common in the vicinity of Pescadero Marsh. In addition to being a candidate species for the endangered or threatened list, the plover is also a Species of Special Concern in California (Remsen, 1978). Sea duck and geese use the coves along the bay for staging during spring migration. Ano Nuevo Bay is an important wintering site for Harlequin ducks (a Species of Special Concern).

Table 3 Representative Seabirds and their Seasonal Status in the Monterey Bay Area (from Briggs, et al., 1983).

Breeding Species

Double-crested cormorant
Brandt's cormorant
Pelagic cormorant
Western gull
Caspian tern
Tufted puffin
Snowy Plovers
Forster's tern
Common murre
Pigeon guillemot
Marbled murrelet
Rhinoceros auklet
Brown pelican (until 1959)

Winter resident/visitors

Common loon
Arctic loon
Western grebe
Red-necked grebe
Laysan albatross
Northern fulmar
Black scoter
Surf scoter
Harlequin duck
Herring gull
Glaucous gull -WINGED ?
Black-legged kittiwake

Spring/autumn migrants

Flesh-footed shearwater
Mottled petrel
Brant
Red phalarope
Horned puffin
Pomarine jaeger
Long-tailed jaeger
South Polar skua
Laughing gull
Sabine's gull
Arctic tern
Common tern

Summer/autumn (nonbreeding) residents/visitors

Buller's shearwater
Black-footed albatross
Pink-footed shearwater
Sooty shearwater
Black-vented shearwater
Black storm-petrel
Royal tern
Elegant tern
Xantus' murrelet
Ashy storm-petrel

Rarities

Yellow-billed loon
Short-tailed albatross
Cape petrel
Greater shearwater
Least storm-petrel
Red-billed tropicbird
Brown booby
King eider
Black tern
Thick-billed murre
Black skimmer
Little gull

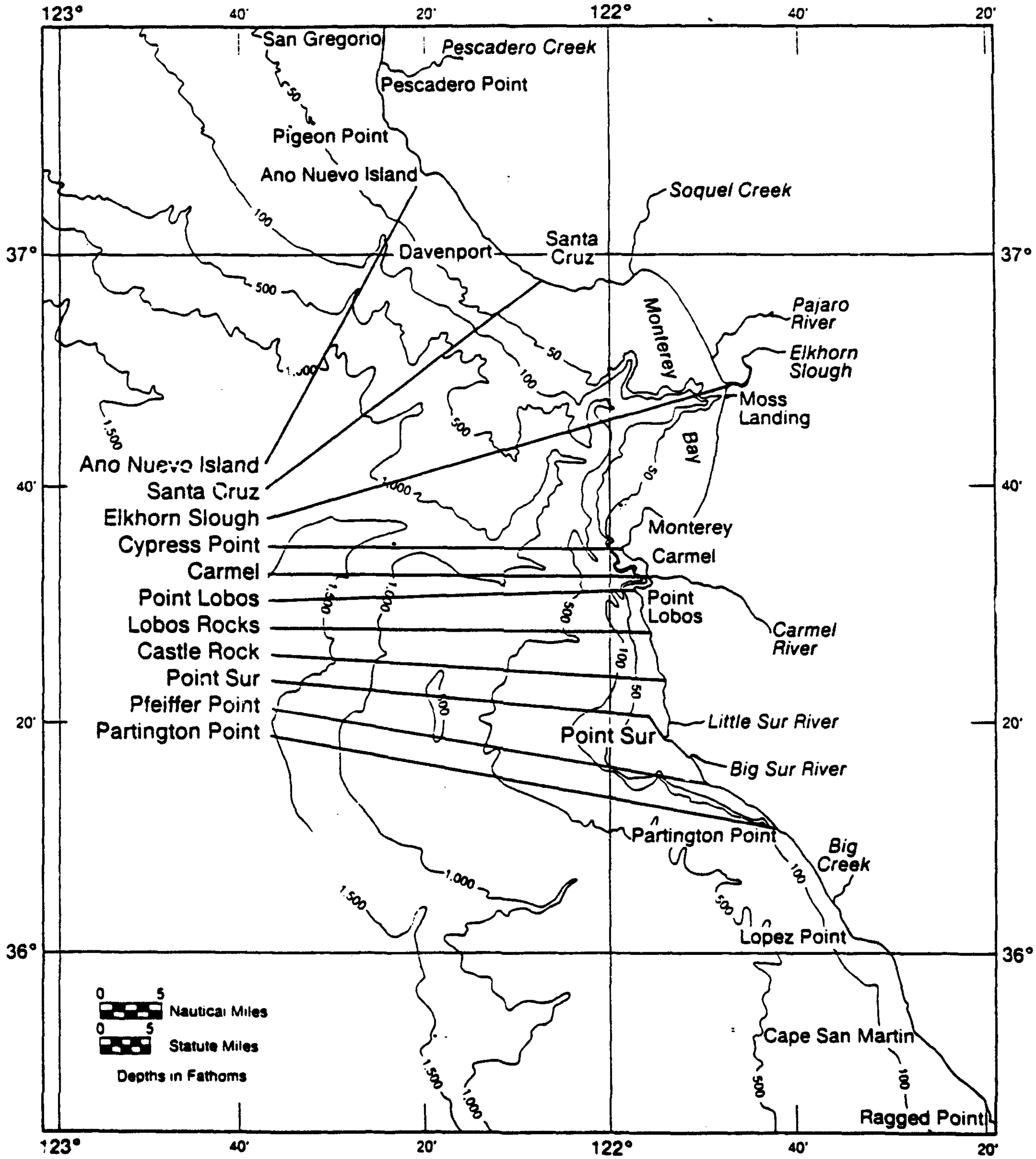


Figure 4 Location of Important Seabird Nesting Areas (U.S. Fish and Wildlife Service, 1981; in NOAA, 1982).

MARINE MAMMALS

Twenty-six species of marine mammals have been observed in the Monterey Bay area, including five species of pinnipeds (seals and sea lions), one fissiped (the sea otter), and twenty species of cetaceans (whales and dolphins) (Table 4). Figure 5 shows the principal sea otter and pinniped breeding and haulout areas.

Of the twenty species of cetaceans seen in the Monterey Bay area (Table 5), about one-third occur with frequency. Common species of whale which are observed include the Gray whale (during it twice-yearly migration), and the Blue whale (late spring through late autumn). Pilot whales, false killer whales, and two species of rare beaked shales have also been sighted. Killer whales have been seen throughout the bay, occasionally attacking gray whales (Baldridge, 1972). Two species of porpoise are commonly found in the bay: Dall's porpoise and the harbor porpoise. The harbor porpoise is usually found over sandy bottoms just off the surf in the north central part of the bay. Dall's porpoise is seen frequently along the edge of the canyon. Pacific white-side dolphins, northern right whale dolphins, and Risso's dolphins are the most numerous cetaceans in the area. All three species will often travel together in a school. Bottlenose dolphins are found in small numbers (12-18) within the bay seemingly on a year-round basis. Common dolphins are found all year, sometimes in schools of 400-600 animals. This species is normally considered a warm water animal and was once thought to extend north only to Point Conception.

ENDANGERED, THREATENED & CANDIDATE SPECIES

Ten species of marine mammal are federally listed as either threatened or endangered at the present time. The are: Stellar's sea lion, Guadaloupe fur seal, Southern sea otter, Gray whale, Right whale, Blue whale, Fin whale, Sei whale, Humpback whale, and Sperm whale.

The numbers of the Stellar's sea lion have been declining throughout its range over the last 30-year period. Due to this rapid decline in the species NOAA published in April 1990 an emergency rule, listing the Stellar sea lion as threatened to be followed by a permanent ruling. Ano Nuevo Island, 20 miles northwest of Santa Cruz Harbor, has the largest breeding population of Stellar (northern) sea lions south of Alaska (Loughlin et al., 1984).

The Guadaloupe fur seal once ranged from the Farallon Islands, off the coast near San Francisco, to Baja California, including the Monterey Bay area. By the first years of this century it was thought to have become extinct due to hunting by humans. It was rediscovered on Guadalupe Island, off northern Baja California, in 1926. Under endangered species protection by both U.S. and Mexican governments the seal's numbers are growing. Two hundred forty were counted on Guadalupe Island in 1964. None have taken up permanent residence in the vicinity of Monterey Bay but there have been reports of sick animals stranded on the area's beaches. One juvenile male was found along the shore near Fort Ord, 20 miles south of Santa Cruz Harbor, in April 1977 (Webber and Roletto 1987).

Table 4 Marine mammals found in the Monterey Bay area. Status abbreviations: SR - seasonal resident, YR - year-round resident, ST - seasonal transient (A. Baldridge, pers. comm., in Heimlich-Boran, 1988)

Common Name	Genus/Species	Status
PINNIPEDS:		
California sea lion	Zalophus californianus	SR
Steller sea lion*	Eumatopias jubatus	SR
Northern elephant seal	Mirounga angustirostris	SR
Northern fur seal	Callorhinus ursinus	ST
Guadelope fur seal **	Arctocephalus townsendi	ST
Harbor seal	Phoca vitulina	YR
FISSIPED:		
Southern sea otter *	Enhydra lutris	YR
CETACEANS:		
California gray whale **	Eschrictius robustus	ST
Blue whale **	Balaenoptera musculus	ST
Fin whale **	Balaenoptera physalus	ST
Minke whale	Balaenoptera acutorostrata	SR
Humpback whale **	Megaptera novaengliae	ST
Pacific right whale **	Eubalaena glacialis	ST
Sperm whale **	Physeter catadon	ST
Pygmy sperm whale	Kogia breviceps	ST
Baird's beaked whale	Berardius bairdi	ST
Cuvier's beaked whale	Ziphius cavirostris	ST
Short-finned pilot whale	Globicephala macrorhynchus	ST
Killer whale	Orcinus orca	ST
False killer whale	Pseudorca crassidens	ST
Risso's dolphin	Grampus griseus	SR
Pacific white-sided dolphin	Lagenorhynchus obliquidens	SR
Northern right whale dolphin	Lissodelphis borealis	SR
Dall's porpoise	Phocoenoides dalli	SR
Harbor porpoise	Phocoena phocoena	SR
Bottlenose dolphin	Tursiops truncatus	ST
Common dolphin	Delphinus delphis	ST

** Endangered * Threatened

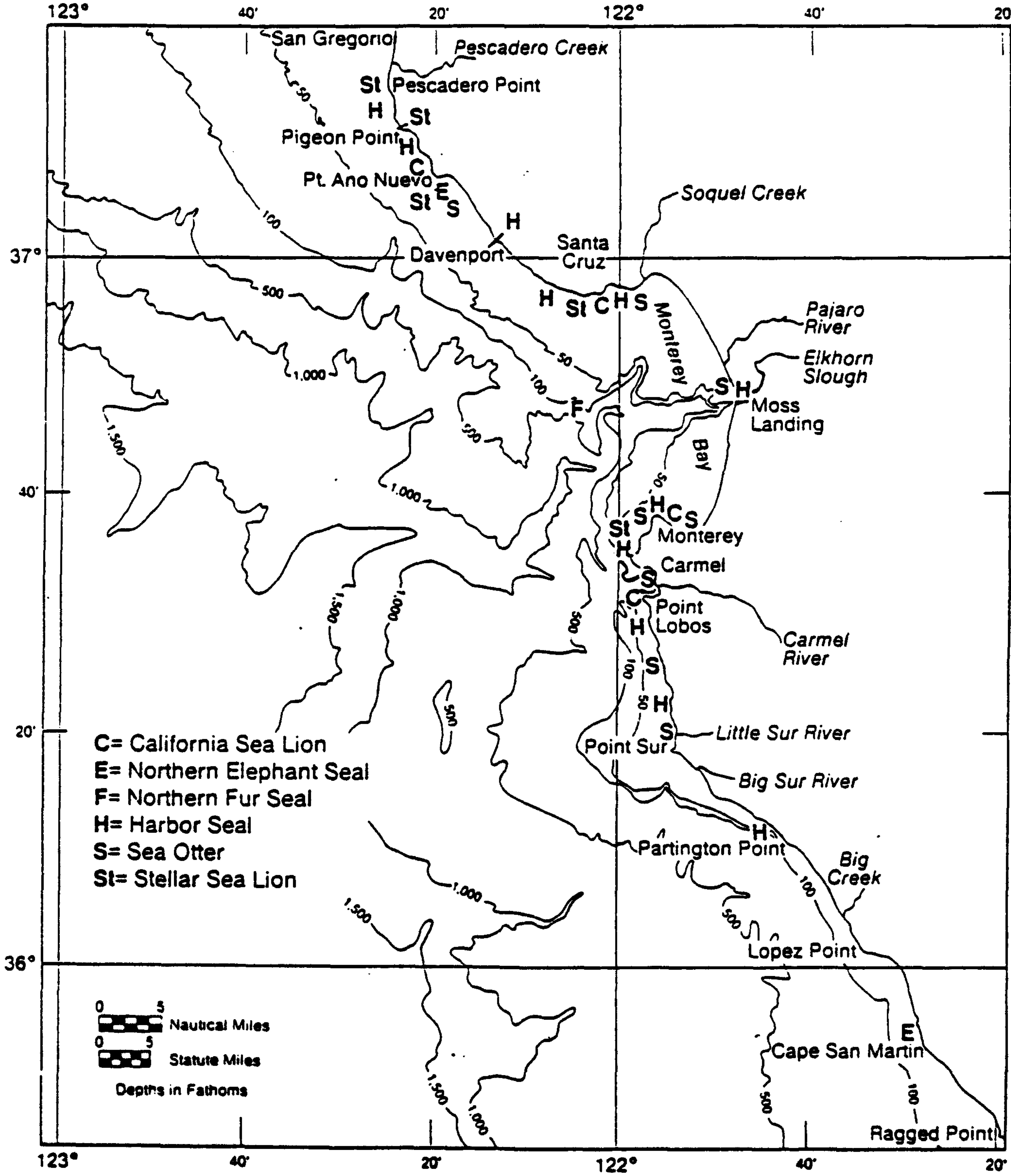
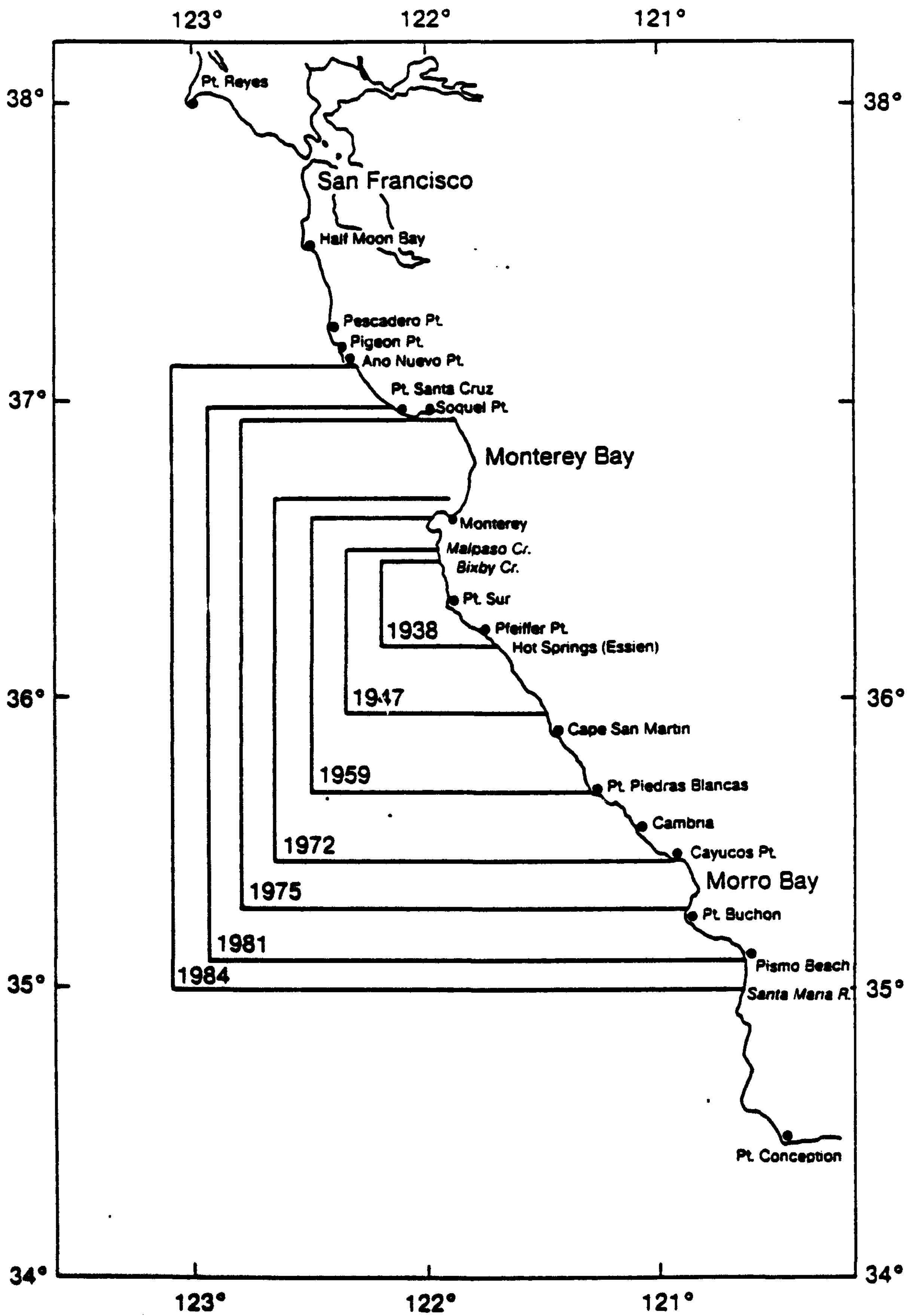


Figure 5 Principal Sea Otter and Pinniped Areas of Concentration in the Monterey Bay Area (U.S. Fish and Wildlife Service, 1981; California Department of Fish and Game, 1980; in NOAA, 1982).

The California or southern sea otter is also a federally listed threatened species that is found throughout the shallow waters of Monterey Bay from Point Pinos to Ano Nuevo Island. Sea otters inhabit a narrow zone of coastal waters, normally staying within about one mile from shore. They forage in both rocky and soft-sediment communities as well as in the kelp understory and canopy. They seldom are found in open waters deeper than 30 m, preferring instead the kelp beds which serve as vital resting, foraging, and nursery sites. Otters are an important part of the marine ecosystem. By foraging on kelp-eating macroinvertebrates (especially sea urchins) sea otters can, in many instances, influence the abundance and species composition of kelp assemblages and animals within nearshore communities (Riedman, 1987).

The California sea otter population is a remnant of the North Pacific population that was decimated by the commercial fur trade in the 18th and 19th centuries. In 1914, this population in California occupied a few miles of the rocky Point Sur coast and was estimated to contain about 50 otters. By 1938, when the public became aware of these remnant otters, the total California population was between 100-300 animals. Between 1938 and 1976 the population increased at about 5 percent per year. From 1976 until the early 1980's, the population did not grow at all, mainly because of the number of otters drowning from entanglement in fishing nets. Since state legislation restricted the use of entangling nets, spring population counts may be increasing at about 8 percent per year (Saunders, 1989). However, this population growth rate is still much lower than the growth rates of sea otter populations in the Aleutain Islands. In addition to the entanglement in fishing nets, other possible factors for the low population growth include illegal shooting, white shark attacks, pathological disorders, starvation, and adverse weather conditions. The most recent census (1988) indicates a total population of fewer than 1800 animals (Saunders, 1989). Approximately 31 percent of this population is currently found in the area from Point Sur north to Ano Nuevo/Pigeon Point. Figure 6 shows the rate of sea otter range expansion from 1914 to 1984.

Gray whales are seasonal migrants. They travel close to shore and are the object of most of the whale watching in the area. They pass through the area twice on their yearly migration from Alaska to Baja California where they breed and then return. Reilly (1984) estimated the 1980 population of gray whales to be 15,000 animals. Blue whales have significantly increased in numbers within and adjacent to Monterey Bay. Once considered only a summer visitor of limited numbers, blue whales have become a major constituent of the cetacean fauna from late spring until late autumn or early winter. Over 40 animals were counted in one day in Monterey Bay in the summer of 1986 (Dohl, pers. comm., 1989). Less than 2,000 blue whales exist in the eastern north Pacific (Haley, 1987). They migrate from northern feeding areas to waters off Baja California and Central America in the fall. Minke whales are one of the largest whales that feed close to shore within Monterey Bay. Up to 12 animals are regularly seen in the southern bight of the bay and south to Point Sur during summer (Baldridge, pers. comm., in Heimlich-Boran, 1988). Fin whales have increased in numbers and length of stay in the area in recent years. This species utilizes the Monterey, Soquel, and Carmel canyons for feeding. They are found in greatest numbers at the heads of each of these canyons in



42 Figure 6 Rate of Range Expansion (1914-1984) of the California Sea Otter Population (Reidman, 1986).

depths of 200 m to 2000 m (Dohl, pers. comm., 1989). Humpback whales are often seen in nearshore waters from 100 m to 200 m depth. Although still an endangered species, their numbers have increased dramatically throughout central California beginning in the early 1980's. At first limited to the general area of the Farallon basin, they are now found in coastal waters from Point Sur to Pillar Point from late-April to mid-December. The Pacific Right whale is an extremely endangered species. Fewer than 200 individuals may inhabit the entire North Pacific (Braham and Rice, 1984). Little is known about this species; its breeding areas are unknown but presumed to be on their wintering grounds in warmer waters. No right whales have been seen in Monterey Bay, but they were seen in 1986 and 1987 in the waters off of Half Moon Bay, north of Ano Nuevo (Scarff, 1987). Sperm whales are occasionally seen offshore at the mouth of the Monterey Canyon.

Four species of endangered birds which are found in the area are: Brown pelican, California least tern, Short-tailed albatross, and Peregrine falcon.

The California brown pelican formerly nested at Point Lobos until 1959 (Baldridge, 1973). No records of nesting have occurred since that time. Noticeable declines in the population began after World War II and are generally attributed to the use of chlorinated hydrocarbons such as DDT. Numbers reached a low point in the early 70s, but, following the banning of DDT, birds have begun to return in force. The brown pelican now breeds in waters of southern California and Mexico and migrate into the Santa Cruz area in large numbers in July and August. They currently roost on Ano Nuevo Island, Elkhorn Slough, and Point Lobos. Some nesting behavior has been observed since 1984 at Pt. Lobos again.

The California least tern nested on the sandy beaches at Moss Landing early in the century. None is known to have bred in the area after 1955. In 1973, the coast south of San Francisco contained on 20 colonies with a total of fewer than 700 pairs (Udvardy, 1977). Presumably this entire population migrates along the coastline of Santa Cruz county, but actual records are scarce. Roberson (1985) states an average of only 5-7 birds per year in Monterey County, immediately south of Santa Cruz, during the spring and fall migrations. It status is endangered due to loss and disturbance of its sandy beach nesting habitat.

The Short-tailed albatross is close to extinction due to its destruction by the feather industry, carried on in other parts of its range. According to Peterson (1961), the last sighting of the bird off the California coast was in 1946.

The Peregrine falcon is a rare breeder along this part of the California coast. Before its numbers suffered substantial declines due to pesticides, it was believed to have been more regular, both as a nesting bird and in winter. Peregrine falcons feed along the shores of the bay, especially around Point Lobos and Elkhorn Slough. Five nests have been identified in Big Sur. (Roberson, 1985). It has been observed on recent Audubon Christmas Counts in Santa Cruz County.

There are two additional species which appear on the list of endangered and threatened included with this document. They are Santa Cruz long-toed salamander and the San Francisco garter snake. They do not appear in the lists of marine animal resources in the DEIS/MP nor are they discussed there. Further clarification of the precise geographic range of these animals will need to be obtained. This is also true of several of the species that appear on the candidate species list: This will require additional research on the part of the Service.

We feel fairly certain that six federally listed candidate bird species probably occur in the Santa Cruz area: Marbled murrelet, Elegant tern, California horned lark, Tricolored blackbird, Xantus' murrelet and Western snowy plover. This last species, the western snowy plover, is being proposed for listing as threatened by the U.S. Department of the Interior at the time of this writing.

The Marbled murrelet, although recorded year-round in the region, is considered a rare visitor to coastal waters. It may nest somewhere on the Big Sur coast. The first known nest site in North America was discovered in Big Basin Redwoods State Park in Santa Cruz County in 1975 (Binford et al 1975). Twenty murrelets were observed in a recent Audubon Christmas Count in Santa Cruz County (LeBar 1989). Most records in Monterey County, adjacent to Santa Cruz, have been noted between early September and mid-February (Roberson 1985).

The Elegant tern is a common post-breeding summer visitor along the coast around Santa Cruz. They do not seem to have occurred before 1957 (Roberson 1985). Since the 1960-70s records show that these birds arrive in early May, peak from late July to early October, and have migrated out of the region by the end of December. Their range appears to be expanding northward, possibly associated with the increasing population numbers of Northern anchovy.

The California horned lark, an uncommon resident of the area, is very common along the coast of Santa Cruz County in the winter (Roberson 1985). Its habitat is usually open fields and grassy ridges. The birds are occasionally seen on dunes but often the flocks number less than 30 (Gordon, 1974).

The Tricolored blackbird is a locally common resident of cattail ponds. It may have been more widespread as a breeder. Away from favored open fields, cattle pens and marshes, the birds are scarce. It does not appear on beaches (Gordon, 1974). The population numbers swell by migrants from the Central Valley in the fall and winter (October-April).

Xantus' murrelet is an uncommon post-breeding visitor to offshore waters from July through October, rare in the winter and spring. Its relative abundance may be tied to water temperatures; seemingly less common in very warm water years. It is most often found 3-10 miles offshore, and only occasionally observed from shore (Roberson, 1985).

The Western snowy plover is a local breeding species on sandy beaches and salt flats. Numbers increase in winter with the arrival of migrants (Roberson

1985, Page 1988). Some of Santa Cruz County's breeding plovers are resident, but others leave the area during the winter. Migrants from other populations appear on beaches in early July and add to the total number of plovers. Most of these migrants depart during early spring (Warriner & Warriner 1981).

POTENTIAL IMPACTS

Six alternatives are being investigated under the Santa Cruz Harbor Shoaling reconnaissance study. They include: 1) No Action; 2) Jetty Sealing; 3) Extended Discharge Pipeline; 4) Sand Trap; 5) Fixed Jet Pump System; and 6) Mobile Jet Pump System.

The environmental complexities of sediment, water and biological interactions means that is necessary to review and evaluate the natural disturbance regime at the dredging and disposal sites and its relation with directly associated floristic and faunal communities for effective avoidance of adverse impacts on endangered, threatened and other sensitive species and their habitat.

ALTERNATIVE #2 - SEAL EAST AND/OR WEST JETTY

This measure involves the injection of grout into the currently pervious jetty along its centerline. It would create in essence a 1- to 2-foot wide "concrete/grout curtain" inside the center of the jetty structure. The materials used in the east and west jetties, specifically the granite boulders and concrete tetrapods, simulate to some degree the habitat of exposed and protected outer coast rocky shores. Those portions of the jetties subject to tide and ocean surf may support populations of long-lived animals such as anemones and mussels and more ephemeral populations such as algae.

The extent of the grouting was not fully described. If the grouting were extensive and covered or filled the crevices and voids of the subtidal rock, significant degradation of existing fish and invertebrate habitat could result. If the grout is injected into the interior portions of the breakwater (as was verbally described by Corps personnel during a site visit by the Service) and the outer layer of large stones was unaffected, the principal habitat value to fishes and invertebrates would be retained. In any event, the implementation phase will certainly have adverse impact on the California brown pelican as it may use the jetties for resting.

The Service is also concerned whether the grouting of the breakwater to preclude the movement of sand would thermally insulate the inner harbor from the cooler outside waters. The significance of such a modification to the thermal regime of the harbor is unclear and would need to be addressed.

ALTERNATIVE # 3 - EXTENDED DISCHARGE PIPELINE

This option would consist of the extension of the existing dredge discharge pipe to Black's Point in order to avoid "bypassing reversals" by disposing of the dredge materials further down the shoreline. It would require a permanent anchor/connection point at Black's Point for the discharge

line. The current layout of the discharge pipeline impacts a relatively small area along the shore east of the east jetty. The proposed extension in this alternative would increase significantly the pipeline's footprint, possibly disrupting and/or precluding the beach as useful wildlife habitat.

ALTERNATIVE #4 - SAND TRAP

This measure would result in the excavation of a "pit" over the existing tip shoal and entrance channel at the mouth of the harbor. It would serve to "trap" the transport of sand and increase the time normally required between dredging operations. The dimensions of the pit would be approximately 200' by 100' with centerline depth of 40' MHW with side slopes approximately 3'V to 1'H. It would include the excavation of a clay layer. The actual excavation of the trap will result in disruption and elimination of both epifauna and infauna at the trap site. Excavation operations also may result in minor disruption to the biota residing in the rocky intertidal-like habitat provided by the jetties. The dredging would continue to occur, as now, on a periodic basis, resulting in some degree of unavoidable marine resource damage which cannot be precisely predicted as to its extent and consequences at this time. However, it is not expected to result in the elimination or serious reduction of these resources in this area.

ALTERNATIVE #5 - FIXED JET-PUMP-TYPE SAND BYPASSING SYSTEM

This alternative involves the installation of two jet-pumps in the center of the harbor entrance at about 40' below MHW, and the cavity in which they were located would be sided with slopes of approximately 3'V to 1'H. The system would either use the existing discharge pipeline or parallel it. This option would represent a permanent alteration of the channel bottom. As permanent fixtures on the bottom they may provide surfaces, albeit artificial, conducive to colonization or shelter or other functional habitat for benthic organisms. The damage that ensues from the dredging operations under this configuration is the severe trauma exacted on the benthic epifauna and infauna that are incapable of escaping the dredge intake. During actual operations, this microenvironment could be severely disrupted with consequent adverse impacts on opportunistic species which characteristically colonize the dredged surfaces of the ocean bottom. Of further concern is the effect of the intake velocity on the capability of fishes to avoid or escape from the dredge. It is not clear whether this option would entirely replace the current dredging platform in this part of the harbor channel. If the presence of the platform is not required, its removal would result in certain impacts that would need to be considered.

ALTERNATIVE #6 - MOBILE JET-PUMP-TYPE SAND BYPASSING SYSTEM

This system would consist of a mobile jet pump and most likely be crane operated, bypassing sand from the shore fillet west of the west jetty to east of the east jetty, thus reducing to some extent the amount of sand that is subject to transport into the outer channel and mouth of the harbor, especially during storm events. This option would have direct impact in a distinct area. The crane equipment could have different impacts, such as disturbing potential avian resting sites.

A review of the project alternatives indicates that nearshore sublittoral and/or sandy beach intertidal habitats would likely be directly affected by the implementation of any of the proposed actions. Dredging will severely disturb infauna and epifauna of sandy intertidal and sandy subtidal habitats, and the biological community using the artificial habitat afforded by the jetties. Benthic substrate burrowing invertebrates, substrate surface dwelling invertebrates, and attached vegetation in the immediate area would be lost by dredging operations. All these processes could have adverse impact on the endangered California southern sea otter and California brown pelican.

These operations could also be expected to have a localized short-term adverse affect to water quality and turbidity with potential impact on plant and animal life. The Service is also concerned for the project's potential to influence tide, wind and wave action in such a manner as to prevent or retard adequate flushing of petroleum-based pollutants from the harbor area.

Another issue, the disposal of the dredge spoils, which is associated with each of the alternatives, is already regulated by Section 404 of the CWA and Section 10 of the Rivers and Harbors Act of 1899. Current disposal practices within the Sanctuary are regulated by the Regional Water Quality Control Board (RWQCB) Waste Discharge Requirements (WDR) under the authority of the Clean Water Act. WDRs include prohibitions and discharge limitations including limited time intervals for disposal. In the case of the Santa Cruz Harbor WDR (No. 88-68), there are also provisions that if the spoils are clean enough it should be utilized for beneficial beach nourishment. In the context of the Monterey Bay National Marine Sanctuary program, it has been proposed that NOAA works within this existing process to ensure that WDR requirement are in place, enforced and adequate to protect the resources of the Sanctuary.

Regulations under Title I of the MPRSA prohibit ocean disposal of dredged material which proves to be toxic to the organisms of the disposal site. Ocean disposal of any materials dredged from a site where pollution is possible must be preceded by bioassay tests to determine the effect on aspects of the marine environment.

The different alternatives may generate different quantities and possibly qualities of sediment spoil which could have results detrimental to the biotic communities. Anecdotally, however, this did not seem to be the case during an on-site visit, when shorebirds lined up at the end of the discharge pipeline waiting patiently for a meal to appear.

The biological assessment conducted for these alternatives must include potential project affects to the federally listed endangered and threatened species. In addition, there are several federal candidate species which should be considered. These latter candidate species belong to taxa for which the Service has either substantial information to support listing as threatened or endangered, or taxa that may warrant listing but for which substantial information to support a proposed rule is lacking. Most of the species which are listed as endangered or threatened or are candidates for listing appear not to be significantly affected by any of the project alternatives, either separately or in combination. The California southern

sea otter, California brown pelican, and the Western snowy plover would be vulnerable to impacts under any of the alternatives, especially #3 involving an extension of the discharge pipeline along the beach. Whether any plovers have been observed along the stretch of beach that would be subject to the footprint of any extension is not known; nor is it known precisely how much long-term value this beach could provide to the plover given other human activities in the area.

RECOMMENDATIONS

In general, additional, site-specific data is needed to more accurately assess the project alternatives' potential impacts on biological resources. For instance, there is some obvious use of the waters in and around the harbor by the California southern sea otter. But the data on which this conclusion is based is not sufficiently detailed to accurately estimate when and to what extent the project may present a threat to the otter. Another instance regards our present knowledge of the Brown pelican's utilization of the immediate project area. It is known that the bird does use the area but, again, the extent of this usage has not been detailed or quantified. This means that more data must be systematically collected at the appropriate time(s) of the year and analyzed for potential impact.

Since the dredging will be an on-going maintenance operation during the winter months, the Corps should obtain an reasonable estimate of the nature and intensity of utilization by at least the California brown pelican, the California southern sea otter, and the Western snowy plover. With respect to the pelican, the Corps should be able to design the implementation of any of the alternatives to assure that construction operations are compatible with the bird's resting and foraging needs. The same must be advised regarding the otter and the plover. With respect to the latter a winter and spring survey with the object of obtaining more pertinent, site specific data, should be undertaken to assess the potential effects the project, especially Alternative #3, may have on this species.

It is recommended that before the sand trap alternative is implemented, an adequate random sample from the proposed excavation site and an analysis performed be taken in order to ascertain the composition and abundance and significance of the infauana in the excavated bottom. Our principal concern is whether sea otter food resources would be removed in significant amounts.

Dredge spoils should be monitored before and after any project implementation. The results from tests associated with past maintenance dredging operations in the Santa Cruz Harbor should be evaluated to assure the quality of the dredged material. A more explicit physical description of the dredged material, its quantity and its behavior in the receiving water during discharge will be necessary before environmental impact can be precisely defined.

It is recommended that a thorough review be undertaken of available data from laboratory and field studies dealing specifically with sediment effects on estuarine biota of the harbor and nearshore habitat.

Before implementing the extension of the discharge pipeline (under Alternative #3), the Corps should assure that a survey to determine the specific plant and animal populations that may be impacted should be undertaken. It should include evaluation of the affected beach as a nesting resource for avian fauna and potential haul out sites for marine mammals.

Also it is recommended that impacts associated with the maintenance of the extended discharge pipeline be identified and assessed. The same would be required for the permanent anchor/connection site at Black's Point. Both short- and long-term impacts would need to be considered.

Further information concerning the distribution and abundance of Necomb's littorine snail is needed before the Service will be able to judge the significance of the proposed project alternatives on its well-beings.

We estimate that it will require 12 biologist days to obtain the necessary field data on the sea otter, Brown pelican and snowy plover, and to further research the vulnerability of Newcomb's littorine snail.

Table 6 contains a list of tasks and associated costs which the Service may provide in further assistance with the project. An additional 33 biologist days would be needed to obtain and analyze additional data and to write a report. The cost for these services would be approximately $15,000.

The Service appreciates the opportunity to review and comment on the proposed study and to provide this planning aid. In order to expedite Service review, please direct all future correspondence regarding this project to the Laguna Niguel Field Station. Should you require additional information regarding this matter, please contact Mr. John Bradley of my staff at the letterhead address or (714) 643-4270.

Sincerely,

for

Brooks Harper
Office Supervisor

Attachment: 1) References Cited and Used in Planning Aid Letter (5 pp)

2) List of Endangered and Threatened Species and Candidate Species That May Occur in the Area of the Santa Cruz Harbor Shoaling Project, Santa Cruz, California (2 pp)

TABLE 6

TASK DESCRIPTION AND COSTS

	Description	Biologist Days
1.	Obtain detailed information with respect to use of harbor area by California sea otter, California brown pelican, and Western snowy plover. Includes biotic survey of shoreline affected by proposed extension of discharge pipeline.	10
2.	Review of available laboratory and field data with respect to sediment effects on intertidal and near-shore subtidal biota.	5
3.	Obtain additional information on Newcomb's littorine snail and further evaluate potential project impacts on the animal.	3
4.	Perform survey of permanent anchor/connection site at Black's Point.	2
5.	Perform data analysis and evaluation.	7
6.	Write report.	6

	Total Biologist Days	33
7.	Total costs: (@ $457.00 per day)	$15,081

REFERENCES CITED AND USED IN PLANNING AID LETTER

Abbott, I.A. and G.J. Hollenberg. 1976. Marine Algae of California. Stanford University Press, Stanford, CA. 827pp

Baldridge, A. 1972. Killer Whales Attack and Eat a Gray Whale. J. Mammal. 53:898-900.

____________. 1973. The Status of the Brown Pelican in the Monterey Region of California: Past and Present. Western Birds 4:93-100.

Barham, E.G. 1956. The Ecology of Sonic Scattering Layers in the Monterey Bay Area. Stanford University, Hopkins Marine Station Thesis. 182 pp.

Beck, R.H. 1910. Water Birds of the Vicinity of Point Pinos, California. Proceedings of California Academy of Sciences, 4th Ser., 3:57-72.

Binford, L.C., B.G. Eliott, and S.W. Singer. 1975. Discovery of a nest and the downy young of the Marbled Murrelet. Wilson Bull. 87:303-319.

Bonnell, M.L., M.O. Pierson, and G.D. Farrens. 1983. Pinnipeds and Sea Otters of Central and Northern California, 1980-1983: Status, Abundance, and Distribution. Prepared by Center for Marine Studies, University of California, Santa Cruz, for the Pacific OCS Region, Minerals Management Service, U.S. Dept. of the Interior. OCS Study MMS 84-0044. 220 pp.

Braham, H. and D.W. Rice. 1984. The Right Whale, Balaena glacialis. Mar. Fish. Rev. 46:38-44.

Breaker, L.C. and W.W. Broenkow. 1989. The Circulation of Monterey Bay and Related Processes. Moss Landing Marine Laboratories Tech. Pub. 89-1.

Briggs, J.C. 1979. Marine Zoogeography. McGraw-Hill Series in Population Biology. New York, NY.

Briggs, K.T., W.B. Tyler, D.B. Lewis, and K.F. Dettman. 1983. Seabirds of Central and Northern California, 1980-1983: Status, Abundance, and Distribution. Center for Marine Studies, University of California, Santa Cruz. 237 pp.

Briggs, K.T., and E.W. Chu. 1986. Sooty Shearwaters Off California: Distribution, Abundance, and Habitat Use. Condor 88:355-364.

____________________. 1987. Trophic Relationships and Food Requirements of California Seabirds: Updating Models of Trophic Impact. Pp. 279-304 In: J.P. Croxall (ed.), Seabirds: Feeding Ecology and Role in Marine Ecosystems. Cambridge University Press, Cambridge, England.

California Department of Fish and Game. 1979. Living Marine Resources of the Proposed Monterey Bay Marine Sanctuary. 25pp.

Cink, C.L. and R.L. Boyd. (Eds). 1988. The 87th Christmas Bird Count. American Birds 41(4):1234-1307.

_____________________________. 1989. The 88th Christmas Bird Count. American Birds 42(4):1129-1130.

Dohl, T.P. 1983. Marine Mammals and Seabirds of Central and Northern California, 1980 - 1983; Synthesis of Findings. Center for Marine Studies, University of Santa Cruz. Report on Contract No. 14-12-001-29090 to Pacific OCS Region, Minerals Management Service, U.S. Department of the Interior, Washington, D.C.

Foster, M.S. and D.R. Schiel. 1985. The Ecology of Giant Kelp Forests in California: A Community Profile. U.S. Fish and Wildlife Service Biol. Rep. 85(7.2). 152 pp.

Foster, M.S., A.P. De Vogelaere, C. Harrold, J.S. Pearse, and A.B. Thum. 1988 Causes of Spatial and Temporal Patterns in Rocky Intertidal Communities of Central and Northern California. Memoirs of the California Academy of Sciences. No. 9.

Fredette, T.J., D.A. Nelson, T. Miller-Way, J.A. Adair, V.A. Sotler, J.E. Clausner, E.B. Hands, and F.J. Anders. 1990. Selected Tools and Techniques for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites. Prepared for Department of the Army, US Army Corps of Engineers. Tehnical Report D-90-11. Final Report.

Garrison, D.L. 1979. Monterey Bay Phytoplankton. I. Seasonal cycles of Phytoplankton Assemblages. J. Plankton Res. 1(3):241-264.

Gordon, B.L. 1977. Monterey Bay Area: Natural History and Cultural Imprints. Boxwood Press, Pacific Grove, CA. 321 p.

Greene, H.G. 1977. Geology of the Monterey Bay Region. U.S. Geological Survey Open-File Report 77-718.

Haley, D. 1987. Marine Mammals. 2nd revised edition. Pacific Search Press. Seattle, WA.

Hanan, D., J.P. Scholl, and S.L. Diamond. 1987. Harbor Seal, Phoca vitulina richardsi, Census in California, June 2-5, 30, and July 1, 1986. Final Report to the National Marine Fisheries Service, Southwest Region. Administrative Report SWR 87-341p.

Harvey, J.T. 1979. Aspects of the Life History of the Blue Shark, Prionace glauca L., in Monterey Bay, California. Master's Thesis, San Jose State University. 105 pp.

Hauschildt, K.S. 1985. Remotely Sensed Chlorophyll and Temperature Distributions Off Central California and Their Potential Relations to Commercial Fish Catches. M.A. Thesis, San Francisco State University. 154 pp.

Heimlich-Boran, J.R. 1988. Marine Resources and Human Activities in the Monterey Bay Area. Center for Environmental Education, April 1988.

Holton, R.L., R.D. Leatham, and G.F. Crandell. 1977. Zooplankton.

Chapter IV in: Winzler & Kelly Consultants (eds). A Summary of Knowledge of the Central and Northern California Coastal Zone and Offshore Areas; Vol. II: Biological Conditions. NTIS PB-274 212.

Lewis, D.B. and W.B. Tyler. 1987. Cliff and Island Nesting Birds. Pp 78-109 In: Management Recommendations for Coastal Terrace and Island Resources at Ano Nuevo State Reserve. Final Rep. to Calif. Dept. of Parks and Recreation, Ano N[illegible]o State Reserve.

Loomis, L.M. 1895. California Water Birds. No. I-Monterey and Vicinity from the Middle of June to the End of August. Proceedings of California Academy of Sciences, 2nd Ser., 5:177-224.

__________. 1896. California Water Birds. No. II-Vicinity of Monterey in Midwinter. Proceedings of California Academy of Sciences, 2nd Ser., 6:1-30.

Loughlin, T.R., D.,J. Rugh, and C.H. Fiscus. 1984. Northern Sea Lion Distribution and Abundance: 1956-1980. J. Wildl. Manage. 48(3):729-740.

Marine Recreation Fisheries Statistics Survey for Northern and Central California, Quarterly Report No. 30, October to December 1986. California Department of Fish and Game, Marine Resources Administrative Report No. 87-9, 1987.

Martin, B. D., and K.O. Emery, 1967. Geology of Monterey Canyon, California. Am. Assoc. Petroleum Geologists Bull., v. 51, pp.2281-2304.

Morris, R.H., D.P. Abbott, and E.C. Haderlie. 1980. Intertidal Invertebrates of the Central California Coast. 3rd ed. University of California Press, Berkeley, CA. 761 pp.

Nybakken, J.W. 1982. Marine Biology. Harper & Row. New York, NY.

NOAA Rockfish Recruitment Cruise Reports, 1986-1988 cited on p. 44 of DEIS/MP but not found in Reference Section.

NOAA. 1982. Management Plan for the Proposed Monterey Bay National Marine Sanctuary. Sanctuary Programs Office, National Oceanic and Atmostpheric Administration.

Oakden and Nybakken. 1977. Cited on p. 41 of the DEIS/MP but not found in Reference Section.

Oliver, J., Slattery, P., Hulberg, L., and J. Nybakken. 1977. Patterns of Succession in Benthic Infaunal Communities Following Dredging and Dredged Material Disposal in Monterey Bay. Prepared for U.S. Army Corps of Engineers. Technical Report D-77-27, Under Contract No. DACW39-74-C-0151. Moss Landing Marine Laboratories. Moss Landing, CA.

Page, Gary W. 1988. Nesting Success of Snowy Plovers in Central Coastal California in 1988. Report of: Point Reyes Bird Observatory. Stinson Beach, CA.

Peterson, R.T. 1961. A Field Guide to Western Birds. The Riverside Press. Cambridge, MA. quoted in: B.L Gordon. Monterey Bay Area: Natural History and Cultural Imprints. The Box Press. Pacific Grove, CA. 321 pp.

Remsen, J.V. 1978. Bird Species of Special Concern in California---An Annotated List of Declining or Vulnerable Species. Calif. Dept. Fish and Game, Nongame Wildlife Investigations Project PR W-54-R-9, Wildlife Management Branch Administrative Rep. No. 78-1. Sacramento, CA. 54 pp.

Ricketts, E.F., J. Calvin, and J.W. Hedgpeth. 1985. Between Pacific Tides. 5th ed., Rev. by D.W. Phillips. Stanford University Press. 652 pp.

Reilly, S.B. 1984. Assessing Gray Whale Abundance: A Review. pp. 203-223 In: M.L. Jones, S.L. Schwartz, and S. Leatherwood (eds.). The Gray Whale. Academic Press. New York, NY.

Richards, F.A. (Ed.). 1980. Coastal Upwelling. American Geophysical Union. Washington, D.C. 529 pp.

Riedman, M.L. 1986. Summary of Information on the Biology of the Sea Otter. Volume II, Technical Support Document I, Final Environmental Impact Statement, Translocation of Southern Sea Otters (USFWS).

Riznyk, R.Z. 1977. Phytoplankton. Chapter III in: Winzler and Kelly Consultants (eds). A Summary of Knowledge of the Central and Northern California Coastal Zone and Offshore Areas; Vol. II: Biological Conditions. NTIS PB-274 212.

Roberson, D. 1985. Monterey Birds: Status and Distribution of Birds in Monterey County, California. Monterey Peninsula Audubon Society. Carmel, CA. 266 pp.

Saunders, R.T. 1989. Overview of the California Sea Otter Population: Biology, Status, and Threats. In: Information Submitted by Friends of the Sea Otter to NOAA's Marine and Estuarine Management Division.

Scarff, J.E. 1987. Historic and Present Distribution of the Right Whale (*Eubalaena glacialis*) in the Eastern North Pacific South of 50°N and East of 180°W. Rep. Int. Whale. Comm. Special Issue 10:43-64.

Schoenerr, J.R. 1988. Blue Whales Feeding On High Concentrations of Euphausiids Around Monterey Submarine Canyon. Master's Thesis, Moss Landing Marine Laboratories. 43 pp.

Smith, R.I. and J.T. Carlson. 1975. Light's Manual: Intertidal Invertebrates of the Central California Coast. 3rd ed. University of California Press, Berkeley, CA. 716 pp.

Stenzel, L.E., J Kjelmyr, G.W. Page, and D. Shuford. MS. Results of the First Comprehensive Shorebird Census of Northern and Central California Wetlands, 8-12 September 1988. Draft Report, Point Reyes Bird Obsercvtory. Stinson Beach, CA.

Udvardy, M.D.F. 1977. The Audubon Society Field Guide to North American Birds: Western Region. Knopf. New York, NY. 855 pp.

U.S. Army Corps of Engineers. 1975. Final Environmental Statement: Maintenance Dredging (FY 1975-1976), Santa Cruz Harbor, Santa Cruz, CA. U.S. Army Engineer District. San Francisco, CA.

U.S. Department of Commerce. 1990. Draft Environmental Impact Statement and Management Plan for the Proposed Monterey Bay National Marine Sanctuary. National Oceanic and Atmospheric Administration. National Ocean Service. Office of Ocean and Coastal Resource Management. Washington, D.C.

Warriner, J. and J. Warriner. 1981. Seasonal variation in plover numbers. In: G.W. Page and L.E. Stenzel (Eds) The breeding status of the Snowy Plover. Calif. West. Birds 12:1-40.

Webber, M.A. and J. Roletto. 1987. Two Recent Occurrences of the Guadeloupe Fur Seal, Arctocephalus townsendi, in Central California. Bull. So. Calif. Acad. Sci. 86:159-163.

Wilson, D. 1986. Intertidal Invertebrates of North Moss Landing Harbor and Gibson's Landing Marsh. Resource Planning & Management, Inc. Santa Cruz, CA.

Yellin, M.B., C.R. Agegain, J.B. Pearse. 1977. Ecological Benchmarks in the Santa Cruz County Kelp Forests Before the Reestablishments of Sea Otters. Center for Coastal Marine Studies, University of California, Santa Cruz. Final Report to the U.S. Marine Mammal Commission. Contract MM6AC029. Report No. MMC-76/04. 125 pp.

LIST OF ENDANGERED AND THREATENED[1] SPECIES AND CANDIDATE[2] SPECIES
THAT MAY OCCUR IN THE AREA OF THE SANTA CRUZ SHOALING PROJECT
SANTA CRUZ, CALIFORNIA

LISTED SPECIES

Mammal

Stellar's sea lion	*Eumatopias jubatus*	(T)
Guadaloupe fur seal	*Arctocephalus towsendi*	(T)
Southern sea otter	*Enhydra lutris nereis*	(T)
Gray whale	*Eschrichtius robustus*	(E)
Blue whale	*Balaenoptera musculus*	(E)
Humpback whale	*Megaptera novaeangliae*	(E)

Bird

Brown pelican	*Pelecanus occidentalis*	(E)
California least tern	*Sterna albigrons*	(E)
Short-tailed albatross	*Diomedea albatrus*	(E)
Peregrine falcon	*Falco peregrinus anatum*	(E)

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[1] Legend: Endangered and Threatened Wildlife and Plants

(E) = Endangered
(T) = Threatened
(CH) = Denotes that "critical habitat" has been designated.
(S/A) = Denotes that designated taxon was listed under similarity of appearance provisions of the Endangered Species Act.

[2] Legend: Candidate Wildlife and Plants

(PT): Tax already proposed to listed as threatened

(1): Category "1" candidate for listing; taxa for which the Fish and Wildlife Service (Service) has substantial information to support listing as threatened or endangered.

(2): Category "2" candidate for listing; taxa that may warrant listing but for which substantial information to support a proposed rule is lacking.

(3): Taxa that are not currently being considered for listing as threatened or endangered:

(3a): taxa for which the Service has persuasive evidence of extinction. However, any such taxon is certain to get high priority for listing if rediscovered.

(3b): taxa that currently do not meet the Act's definition of "species". Any such taxon could be reevaluated in the future as a result of subsequent research.

(3c): taxa that apparently more common than previously thought and thus not under current consideration for listing as threatened or endangered.

CANDIDATE SPECIES

Bird

Western snowy plover	Charadrius alexandrinus nivosus	(PT)
Marbled murrelet	Brachyramphus marmoratus	(C2)

Fish

Tidewater goby	Eucyclogobius newberryi	(C2)

Snails

Newcomb's littorine snail	Algamorda newcombiana	(C2)

Appendix D

Social Environment Study

FINAL REPORT
SOCIAL ENVIRONMENT STUDY
SANTA CRUZ HARBOR SHOALING RECONNAISSANCE STUDY

By
Galen Joseph
University of California, Santa Cruz

Under the Direction of
Dr. Richard Lerner, Anthropologist,
U.S. Army Corps of Engineers, San Francisco District

May 1992

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INTRODUCTION

This report is based on 25 in-depth interviews and several more general conversations with individuals, organizations and businesses that use the harbor, are affected by the harbor, and have participated in research and planning for the harbor. The study was carried out over a two and a half month period (mid-January through late March) in 1992. The interviews lasted between 20 and 150 minutes, with an average duration of approximately 45 minutes. Most interviews were carried out at the interviewees' worksites, though a few were held at a restaurant in the harbor and over the telephone. The participants in the study were chosen based on recommendations from the Port District office, as well as from the harbor users. (Throughout this report, I will refer to the people who participated in the study as "harbor users" or simply "users," except where distinctions among them are relevant.)

More than two-thirds of the participants in the study have been involved with the harbor in one form or another for more than 10 years. Thus, the majority of them have watched the harbor struggle with effects of shoaling in the harbor for many years, and in some cases, since the harbor was built in 1963. Some of the more recent arrivals to the Santa Cruz harbor have experienced shoaling problems at other harbors which they used for comparisons during the interviews.

The interviews focused on the how harbor users are affected by shoaling in terms of personal costs, safety and convenience, how the current dredging operation is perceived, and how the seven possible alternatives presently being researched by the Corps of Engineers might reduce shoaling and/or increase efficiency of the current dredging operation. The **primary findings of the study** are that most harbor users are inconvenienced, and many are negatively impacted financially by the effects of shoaling in the harbor mouth and channel. However, there is no

consensus about whether and how the shoaling problems might be addressed most effectively.

Many of the individuals interviewed use the harbor in more than one capacity. While they may have been representing a particular organization, they often also represented their own personal opinion as individual boaters. For example, a Port District Commissioner was interviewed primarily as the president of a property owners association, but clearly also was representing a Port District position as well. Another common situation is when a company provides services for two sectors of the harbor community which are affected differently by shoaling, e.g., one company had both a bait and tackle business and a charter boat business. The kinds of harbor users interviewed in this study can be loosely categorized, however it is important to note that there was a wide range of opinion within each category regarding the current dredging system, the impact of shoaling and the proposed alternatives. Therefore, although I will generally describe the main concerns of each class of users below, my discussion will be organized around the problems caused by shoaling rather than around the different classes of harbor users.

The Classes of Users and Their Primary Concerns

A. The Port District.

This includes: the harbormaster, port commissioners, former port commissioners and the Coast Guard Auxiliary. The Port District class represents over 100 harbor users: the Port District itself employs approximately 35 people, 10-15 of whom work part-time; there are regularly five Port Commissioners in office who often serve multiple four-year terms; and the Coast Guard Auxiliary has up to 62 people involved in the two flotillas it operates.

The primary concern of the Port District is to maintain the harbor in a safe, usable manner for all boaters at the lowest cost possible.

B. Restaurants.

This includes three restaurants and one food stand located in the harbor complex, and represents approximately 200 employees, and thousands of customers who are regular harbor users and tourists. The largest restaurant employs 175 people, of whom half work part-time; one of the smaller restaurants employs approximately 7 people, with seasonal fluctuation.

The main concern of the restaurants is to keep the general activity level in the harbor area high, so as to keep people coming into the restaurants. The most effective method of attaining this activity level is keeping the harbor open. A few harbor users suggested that restaurants and other food services in the area surrounding the harbor are similarly affected by the activity level in the harbor. Likewise, I would guess that other businesses in the harbor, such as those selling bathing suits and clothing, might have similar concerns about keeping the activity level in the harbor high, though none of these businesses were interviewed for the study.

C. Boating Service Businesses.

These include businesses located in the harbor complex that offer supplies and equipment rentals to sport/recreational and commercial boaters. The number of employees ranges from 2 to 14, and the estimated (by business owners) number of customers annually ranged from 400 to 250,000.

The primary concern of these businesses is the same as their customers', i.e. keeping the harbor open and safe for all boaters, including those who are less experienced or skillful.

D. Commercial Boaters.

These include fishermen, charter boat owners and researchers. There are more than 70 commercial fishermen or as many as 160 (according to the Commercial Fisherman's Association and the Port District respectively), and approximately 6 charter and research companies operating primarily (though not always exclusively) out of the Santa Cruz Harbor. Most of the charter boat companies carry 49 passengers per trip, and make hundreds of trips annually.

The primary concern of commercial boaters is to keep the harbor open and passable on a twenty-four hour basis throughout the year, (and especially during the fishing seasons).

E. Educational and Recreational Boaters.

These include clubs, University of California programs, as well as individual boaters and sport fishermen. Club memberships, Yacht and Rowing, are respectively approximately 500 and 70. The UCSC programs, sailing and marine science research, involve more than 1200 people annually.

The main concern of educational and recreational boaters is to maintain safe, reliable access to the harbor and bay. (See Appendix I.)

F. Affected Representatives from the Surrounding Area.

These include individual and commercial property owners East and West of the harbor. The property owners East of the Harbor represented in this study are the 47 members of an association of people who own property on the coast line between the harbor and the city of Capitola. Those West of the harbor who are represented in this study are 200-250 members of the Seabright Neighborhood Association, and the Seabright Corporation which owns the Santa Cruz Boardwalk next to the Santa Cruz city beach.

The pressing concern of property owners East (downcoast) of the harbor is to keep sand bypassing the harbor, i.e. moving downcoast, and not stopping either west of the harbor or in the harbor itself. They are concerned because the cliffs on which their houses sit have been eroding at what they claim is an "unnaturally fast" pace since the harbor was built. (See Appendix II.) Property owners west of the harbor do not have complaints or concerns (and some are enthusiastic) about the build-up of sand on the beaches West of the harbor.

According to the Port District there is a total of 960 floating slips and 275 dry dock spaces in the harbor. The harbormaster reported that while approximately 40% of the boats in the harbor slips are power operated and 60% are sailboats, the percentage of power boats is slowly increasing. The last count of slip distribution among different kinds of boats was carried out by the Port District approximately five years ago. At that time, the average boat size was 27' or 28'. The size slips vary from 20' to 60' with the largest number of slips in the 30' and 40' categories (314 - 30' slips and 129 40' slips). The distribution of types of boats in the slips was:

Commercial vessels (17.70%)[1]

- 160 fishing boats
- 6 large scale charter boats (over 6 person capacity)
- 4 small scale charter boats (6 person capacity)

Educational (UCSC) vessels (3.64%)

- 5 large boats (sailing and research)
- 30 small boats (kayaks and row boats)

[1]The percentages for the kinds of boats are calculated by the author based on the numbers provided by the harbormaster for the total slips and each category of slip users.

Law Enforcement (.41%)

- 2 police
- 1 California State Lifeguards
- 1 Coast Guard (during the summer months)

Other (78.22%)

- 751 remaining slips filled by independent recreational users

Part I

The Problems: How Shoaling Affects Harbor Users Under The Current Dredging System

The current dredging operation, which began with the acquisition of the Seabright dredge by the Port District in 1986, is overwhelmingly viewed by harbor users across classes (who had experience in the harbor prior to 1986) as a profound improvement over any past attempts to address the shoaling problems and keep the harbor open year-round. Participants in this study who had used the harbor for more than six years had at least one story, and sometimes several stories, about the poor results of past efforts to keep the harbor open. All agreed that the harbor is open and usable on a much more reliable basis than prior to the acquisition of the Seabright.

While the current dredging system has vastly improved conditions in the harbor, there remains a low level of enthusiasm among many harbor users. These harbor users seemed to think that it was unlikely that any significant advance could be made in the harbor's continual struggle against shoaling. Many openly stated that they thought the harbor was built in a bad location, and that the Harbor's potential to be open and safe all the time was minimal. A few people said they did not believe that a safe harbor was possible anywhere, let alone at Santa Cruz. The primary reasons given for low enthusiasm for the current system were: (1) Some believed that drought conditions since the acquisition of the Seabright had prevented a "true" test of the system's ability to handle the shoaling when there are severe winter storms, and shoaling is at its worst. (2) The harbor is still not open or the entrance safely and easily passable 365 days a year. Problems include loss of income and inconvenience due to shallowness and narrowness of channel and waves breaking across the entrance. (3) The cost is extremely high, and individual users are affected through rising slip, launch and parking fees. (4) Some people

believe that the shoaling problem will continue to worsen, (i.e., the West beach will continue to grow) and that this dredging operation is therefore not a satisfactory long-term solution.

A. Keeping The Harbor Open in Adverse Weather.

Harbor users discussed the limited ability to keep the harbor open in adverse weather primarily in terms of limits on the Seabright dredge to operate during stormy weather -- the exact time when it is "most needed." Several harbor users argued that because enormous amounts of sand are brought into the harbor during storms, the harbor needs a system that can function effectively during and/or immediately following storms. The Seabright dredge cannot function at these times because it is unsafe for the dredge operators and the dredging equipment.

Two harbor users suggested hiring non-union labor in order to increase flexibility in dredging schedules and reduce dredging costs. They argued that the dredge does not operate at the most needed times because the union contract makes hiring dredge operators for overtime too expensive. Other harbor users suggested that hiring non-union labor was an impractical alternative because they claimed that qualified dredge operators who are not unionized are not available in the Santa Cruz area. Whether the union increases dredging expenses, or whether hiring non-union labor is feasible in Santa Cruz is unclear. It is clear, however, that overtime salaries for dredge operators are higher than the Port District is usually willing to pay. Therefore, dredging is sometimes delayed for a few days until dredge operators come back to work according to their usual schedule. Adverse weather conditions and the high cost of overtime dredging prevent prompt action to keep the harbor channel open 365 days a year. Thus, there are days when the weather has cleared, but the channel is still not passable for some boaters.

B. Depth of the Harbor Channel

To say "the harbor is open" is a relative statement. The entrance to the harbor may be "officially" open when for various reasons some boats may not be able to pass through the channel. The depth of the harbor channel impacts on harbor users depending on the depth of the boat's draw and the time of day (in relation to the tide) that the boater needs access to the bay.

The draw is the depth below water the boat sits when floating. The depth of the draw does not correlate directly to the size of the boat; some large boats have shallow draws, as do small boats such as kayaks and row boats. Motor boats tend to have shallower draws than sailboats. Thus, large and medium sized boats that have deep draws are most affected by the shallowness in the harbor channel.

Some boaters may have no trouble leaving the harbor at high tide, but may not be able to get back into the harbor several hours later when it is low tide. Thus, boating expeditions need to be carefully timed and limited according to the tide schedule. Boaters most affected by the shallowness of the channel during low tides are boaters who need to stay out in the bay for long periods of time, generally fishermen and charter boaters.

The shallowness of the harbor channel which is caused by shoaling seems to most negatively impact boaters who own boats with deep draws, and who need twenty-four hour access to the channel regardless of the tides. That is, charter boat companies and fishermen who have boats with deep draws are the primary users affected by the shallowness of the harbor. They must be able to make both advance commitments and spontaneous decisions, to leave and return to the harbor in order to maintain their businesses. Shallowness in the harbor channel limits the number of hours, and therefore the effectiveness and the earning power of both fishermen and charter boat companies.

Furthermore, according to some harbor users, shallow conditions contribute to the narrowing of the harbor channel which creates unsafe conditions for all boaters. The narrowness of the channel in combination with the presence of the dredge leaves little room for regular traffic to pass through the channel. A couple of harbor users also reported minor accidents in which the bottom of a boat hit the dredge pipeline. It may have been possible to avoid these accidents if the dredge operators had made clear where the pipeline was, however, the shallowness of the channel may have made it impossible to avoid.

C. Wave Conditions

The breaking of waves across the harbor entrance was a serious concern for most of the boaters participating in this study. Some users were careful to make explicit the relationship between the shallowness of the channel and the resulting wave conditions. (Others were content to discuss the two problems, channel depth and waves, separately.)

A common perspective among harbor users interviewed in this study was that the wave conditions were not as bad as they had been before the acquisition of the Seabright dredge. However, the stories many people told about being caught in the waves referred to incidents that occurred after, as well as before, the Seabright was acquired. Most of the stories reported incidents in which boaters lost control, and almost had very serious accidents-- such as, hitting the East jetty, capsizing, running up on the beach East of the East jetty, etc. While the harbormaster reported that since the early 1980s, no fatalities have occurred in the harbor or harbor mouth, many other harbor users told stories of watching accidents, including fatal accidents occur in the mouth of the harbor. The recounting of these accidents, whether factual or exaggerated, seems to demonstrate current trepidations about the harbor experienced by some of its users. The current trepidations also were expressed

directly in accounts of the many days on which the waves break half, three-quarters, or all-the-way across the harbor entrance. According to many users interviewed, it is still at times, an intimidating harbor entrance because of the waves. It is often difficult to navigate, and for some boats, either impossible to cross, or not worth the risk of crossing when the waves are breaking.

Many harbor users agreed that the wave conditions create an unsafe environment which is most hazardous to inexperienced or unskilled boaters, and people unfamiliar with the Santa Cruz harbor. Several harbor users are convinced that "once you know the harbor," it becomes much easier to maneuver even when waves are breaking all-the-way across the mouth, and therefore becomes safer. One user suggested that instead of spending more money on dredging, that money should be used for boater education for everyone who uses the harbor. There is a safe way to leave and enter the harbor, he argued, but the problem is that many people who use the harbor just do not know it. However, it might be unreasonable to expect to educate the large percentage of people who are transient boaters and tourists who may use the harbor only once or only occasionally.

Furthermore, the harbor's role as a Port of Refuge[2] is difficult to adequately fulfill due to the wave action. The times when boaters would be seeking refuge (e.g. stormy weather) are likely to be the times when the entrance to the harbor is least safe, i.e. when waves are breaking across the entrance. At the time they are looking for refuge, there will be no time for boater education.

Businesses supplying to sport fishermen who use their own or rent small boats, and businesses renting small boats claim that their income is negatively affected by wave conditions which limit easy, safe access to the bay. While there

[2]The Port of Santa Cruz was intended to serve as a Port of Refuge according to Congressional House Document 357 (p.15 Art. 27C), 1958. It is therefore supposed to function (and according to the Port District does function) as a safe haven for boats in the Monterey Bay that are caught in stormy weather or are for some other reason in urgent need of returning to land.

does not seem to be any shortage of people interested in using the harbor, as demonstrated by the long waiting lists for slips, a common speculation by business owners in the harbor is that their business might increase if conditions in the harbor were safer. One business that rents small boats currently refuses to rent to inexperienced boaters because it cannot afford the liability risks. Although renters sign a release form, the company is required to report to its insurance company all accidents (e.g. cutting a finger or falling into the water) that occur while using the rental boats. The owner suspects that the reporting of such incidents contributes to the rising cost of liability insurance. Furthermore, the bad publicity that could result for the company if accidents occur while renters are using their boats is not worth the risk of renting when conditions may be unsafe.

The boaters least affected by the rough wave conditions are larger motor boaters who can sometimes drive through between the waves at higher speeds than sailboats. However, given the narrowness of the channel, and the precise timing needed to accomplish this, it is not a safe or reliable option. In addition, the wakes created by motor boats make the water even more rough and difficult for smaller boats to handle.

Commercial fishermen and charter companies who use the harbor at night are especially affected by the wave conditions. In order to safely leave and enter the harbor when the waves are breaking across the entrance, pilots must be able to see the waves so they can time their entrance between breaks. The lack of vision at night creates especially hazardous conditions.

An additional, occasional hazard is surfers. These wave conditions are attractive to surfers, who although it is illegal, occasionally surf in front of the harbor entrance, making it extremely dangerous both for the surfers and for boaters who are not able to see them easily.

D. General Safety

While all users see vast improvement in the ability for the harbor to stay open most days throughout the year, many are still dissatisfied with the condition in which the harbor is maintained.

The shallowness of the harbor, and the associated narrowing of the channel create situations with little or no room for error. This means that boaters must rely on their own skill and the skill of other boaters in the channel. This is a serious risk, because as explained above, many boaters are either unskilled, or unfamiliar with the idiosyncrasies of the Santa Cruz harbor. There is a relatively safe way to enter the harbor in rough conditions, but not everyone who uses the harbor knows it.

For charter boats and businesses that rent boats, the general safety concerns in the harbor are especially problematic because of the liability risks and the possibility of bad publicity explained above (page 12).

E. Expense of Current System

1. Costs

The most obvious and calculable costs of shoaling are experienced by the Port District. The District passes on these costs directly to harbor users in the form of rising slip, launch and parking fees. The total cost of the current dredging operation is estimated by the Port District at $600,000 annually. This includes the direct expense of operating the dredge, liability insurance premiums and output of Port district staff (the harbormaster estimates that 25% of his time and 10% of several additional staff members' time is spent on dredging related activities). The impact of the shoaling problems is especially daunting at this time because of the Port District's loss of income from property taxes (10% of current Port budget) over the next five years. (It is being phased out until 1997 when the Port District will receive

no income from the city of Santa Cruz tax base). Many harbor users commented on the fact that Santa Cruz harbor is much more expensive than neighboring harbors such as Moss Landing and Half Moon Bay. Furthermore, several of the harbor users said they expect the cost of the dredge operation to continually increase. Leaving aside inflation as a contributor to increasing costs, the shoaling problem is expected to worsen if the beach West of the West jetty continues to grow as these harbor users anticipate.

2. Loss of Income

Businesses in the harbor agreed that maintaining a high general activity level in the harbor is vitally important to their survival. When the harbor is closed, or unsafe to use easily, the general activity level declines. Some businesses serving boaters and potential boaters believe, that while not measurable, the issue of safety in the harbor is possibly a psychological factor which intimidates people, and keeps a certain number of people away from the harbor who otherwise might use it. While it was not possible to assess the psychological factor as a direct loss in income in this study, it might be considered a loss in potential income.[3]

Only some businesses and commercial boaters were able to provide rough estimates of financial losses due to shoaling in the harbor. These figures were calculated by harbor users according to their income schedules, i.e. annually, per day, per weekend. The number of days and weekends that they are affected varies each year partly in conjunction with stormy weather, and thus it is difficult to translate them into annual figures and come up with a total annual loss. Therefore, the data

[3] I believe that in order to assess the direct loss in income due to conditions in the harbor that discouraged people from using the harbor, one would need to calculate the number of people who do not use the harbor who would use it if they believed it was safe, and multiply it by the amount of income each of these non-harbor users would generate for businesses in the harbor and the Port District. Such an assessment was beyond the scope of this study.

below should function as general information and should be regarded as rough estimates.

- Boat supply and charter company: $20- $10,000 per weekend depending on wave conditions
- Restaurant: 10% of winter business
- Port District: annually

    1.Launch ramp fees: $22,000

    2. Transient Boater Guest Berthing: $5600-$7000

    3. Parking Fees - $4000-$5000

    4. Fuel sales -$10,000 gross

    5. Personnel Time - $25,000

    6. Dredging - $485,000

- Fisherman: $600 per day
- Fisherman: $2000 per day (variation in fishermen's losses depends on size of boat and whether they cannot go out at all, or must return early because of the tides)
- Charter company $3,000-$3,500 per day (when trips must be cancelled)
- Charter company: $1800-$2500 per day (when trips must be cancelled)
- Property owners East of the harbor: tens of thousands of dollars annually.

Several additional harbor users said they definitely thought their income was negatively affected, but were unable to estimate their losses. One business owner noted the problems of slip rents and parking fees continuously rising (to meet the dredging costs) as potentially impacting negatively on the activity in the harbor, and thus on his business.

Approximately 30% of participants in the study said that the shoaling did not have any financial impact, or had only minor, inestimable impacts on their use of

the harbor. Many of these were recreational and educational users, e.g. club members. A few were business owners.

The dangerous conditions in the harbor did not significantly increase boat repair costs for any users participating in the study.

Part II.

Possible Alternatives

In discussing the proposed alternatives with harbor users, many people were reluctant to comment on particular options because they felt unqualified to judge. That is, they did not know enough about shoaling or the particular alternatives proposed to comment on how a particular system might work. Thus, approximately one-third of all participants in the study did not give an opinion for each option. Some of those who did not give an opinion said "let the experts decide," or suggested modeling the various alternatives on a computer before trying any option to really see how they would work.

On the other hand, many people were anxious to give their opinions, and had very strong feelings for and against particular options. In addition to the options the Corps is considering, several people gave other suggestions which will be discussed below.

Within each category of harbor users there was conflicting opinion. For example, the President of the fishermen's association believed that the current system is unsatisfactory and needs substantial improvement. However, two individual fishermen who were interviewed were satisfied with the dredging operations as it is. There was no discernable pattern of association between a particular class of users and a particular alternative based on the data gathered in this study.

A. No Action Alternative

As discussed above, the current dredging system, while not perfect, is respected as a significant improvement over previous methods of addressing the shoaling problems. When presented with the possibility of alternatives, slightly more than half of the users interviewed in this study thought it worthwhile to

invest in some improvement of the current system or change in the primary form of dredging. A large minority of the users interviewed thought it was unnecessary to invest in investigating and implementing any other alternatives in addressing the shoaling problems.

Two suggestions for improving the current system were: (1) year round dredging; (2) finding a place to keep the dredge when it is not operating so that it does not get in the way as much as it does.

B. Seal East and/or West Jetty

Approximately one third of those interviewed strongly favored sealing at least the east jetty. For example, one fisherman in favor of sealing the east jetty suggested that it was an easy alternative that "should have been done years ago" when the west jetty was sealed. Some harbor users claimed that they could see sand moving through the jetty when standing on top of it. Sealing the west jetty, even for those in favor of the east jetty sealing, seemed unimportant because it had already been partially sealed.

One-third of harbor users opposed sealing either of the jetties. Several people said it was a "stupid" idea and a waste of money because the amount of sand that passes through the jetties is too little to reduce the cost of shoaling. However, another charter boat operator declared that the idea of sealing the jetties was "bogus," not because the sand does not move in through the jetties, but rather because it is easier to remove sand from inside the harbor than outside around the tip where it would get shoaled if the jetties were sealed.

The remaining third had no strong opinion on this alternative because it was not clear to them whether it would reduce shoaling and the demands on the dredge.

C. Extension of Existing Dredge Discharge Pipe Towards Black's Point

The views on the pipe extension alternative also divided approximately into thirds. However, there was no consistent alignment of the thirds opposing, favoring and declining to opine regarding extension of the existing discharge pipe and those opposing, favoring and declining to opine regarding the sealing of the jetties.

Those in favor believed it was an easy, relatively inexpensive way to make the dredging operation more efficient. They believed the sand discharged through the pipe did re-enter the harbor. Additionally, a couple of people thought it would improve the beach east of the harbor to move the discharge pipe further downcoast. One harbor user suggested that the pipe be extended under water down to Black's point to improve the movement of sand downcoast to beaches (such as Capitola) that need sand. This harbor user incorrectly believed that such an underwater pipe was used in the San Francisco harbor and was successful there. The San Francisco harbor does not have an underwater discharge pipe system.

Those against the extension of the discharge pipe opposed it primarily because they did not believe the sand that was discharged through it actually re-enters the harbor.

Those who declined to give an opinion did not feel they had enough evidence to prove that the dredged sand returned to the harbor, but believed that if this was so, it might be a worthwhile addition to the dredge operation.

D. Sand Trap in the Harbor Channel

Only a few of the harbor users interviewed thought digging a sand trap in the harbor channel would be a good way to improve the current dredging system. They liked the idea of getting ahead in the battle against the shoaling, of preparing for winter storms.

Approximately one-third of harbor users thought that this alternative would be a waste of time and other resources because they believed the trap could easily be filled up by one storm, and would not provide real protection against the problems caused by shoaling -- waves, shallowness and narrowness of the channel. They argued that it is impossible to predict when a storm will hit, and therefore, that this option is not any more dependable than regular dredging. For example, one harbor user argued, if more than one storm hits within a short time period, the resulting shoaling will be exactly the same as if the dredge were operating regularly. Another harbor user reasoned that the area dredged was just too small to make a difference.

Most people interviewed were not moved to comment one way or the other.

E. Annual Dredging in Front of The Harbor Channel: Hopper Dredge

Without any consistency with the split of opinion on previous alternatives (B & C), the opinion on the Hopper dredge also split approximately into thirds.

The hopper dredge appealed to one-third of harbor users interviewed for primarily two reasons: (1) because it might reduce the annual costs of operating the "Seabright" dredge (2) because it would address the needs of homeowners downcoast who live on eroding cliffs. Some were only in favor of it if dredging were continued with the Seabright, and another alternative such as the pipe extension was also implemented.

Those who opposed this alternative believed that annual dredging would still be necessary and were therefore concerned about the cost of this option. Others opposing this alternative believed that reducing the beach and dredging around the tip of the jetty was unnecessary.

F. Fixed and Mobile Jet Pump Bypassing Systems

Little distinction was made between the fixed and mobile jet pump systems by harbor users evaluating these alternatives. The most common response to both of these options was that the last time a jet pump system was attempted in Santa Cruz, it was a "disaster." Most people were skeptical that a new and improved version of the previous jet pump system was possible in Santa Cruz. A few people had questions about: (1) how effectively a jet pump system could handle debris from the San Lorenzo river; (2) whether the jet pump system could operate effectively inside the harbor channel as well as on the beach outside the channel; and (3) how well the system could be maintained.

A few harbor users believe that the problem with the failed jet pump system was with the people not the system itself. They were, therefore, supportive of attempting a jet pump system again, stating that it might be the best way to address the shoaling problems in the harbor, as well as the downcoast needs for sand. The belief that it could work year round, and possibly get ahead of the problem made this alternative appealing. However, the use of the beaches around the harbor for recreational purposes requires that sand **not** be pumped during the Spring and Summer months. The restrictions on year-round pumping might diminish the appeal of this option. The jet-pump alternatives were also liked by property owners east (downcoast) of the harbor because they believe sand bypassing the harbor would nourish the beaches in front of their homes.

Even harbor users who were supportive, stipulated that it would need 24 hour maintenance. One harbor user expressed concerns about the crane operated mobile system because the crane could attract children who might play unsafely on or around it.

Only one user suggested that the image of the crane might be bad for the harbor. This idea was countered by a restaurant owner who claimed that the

dredge, and the crane if utilized, would attract the attention of customers, creating an object of interest, and a topic of conversation, rather than a bad image.

G. Other Alternatives Suggested by Harbor Users

Breakwater: Putting a breakwater out in front of the harbor entrance seemed like a good option to harbor users who had experience at other harbors along the coast where such a system seemed to be working. (Los Angeles and Newport were given as examples.)

Extending and Widening the Jetties: Extending either the West, or both jetties seemed like the most feasible solution to the shoaling problems for several harbor users. Widening the entrance was also suggested by a few harbor users who were frustrated with the lack of room for error when entering and leaving the channel.

Snow fence on West Jetty to prevent sand from blowing into the harbor. Two harbor users seemed to think that as much sand blows over the top of the West jetty as flows through it. They suggested that a fence be built on the west side of the west jetty so that when sand blows over it, it will fall onto the jetty before it blows into the harbor. This sand could be periodically removed. The theory supporting this suggestion was that dry sand is easier to move than wet sand.

Conclusions

The primary finding of this study are:

1. Harbor users are generally much more satisfied with the current dredge operation than they have ever been in the past.

2. Slightly more than half of harbor users are so seriously affected by problems caused by shoaling (shallowness, wave action, narrowness of the channel, generally unsafe conditions, financial expenses and direct losses) that they are not content to remain with the current system without trying to reduce shoaling and its effects, as well as dredging expenses.

3. A large minority of harbor users are either satisfied with the current dredging system, or pessimistic about the possibility of reducing shoaling and the resulting problems significantly, and are therefore content with the current system.

4. Just over a third of harbor users interviewed believe that they lose money because of the shoaling problems in the harbor, although the specific amount of money lost is difficult to calculate.

This study has demonstrated that shoaling in the Santa Cruz harbor is a serious concern for most harbor users. While there is no consensus on how the shoaling should be managed among the harbor users participating in this study, it is clear that many strongly support a variety of the proposed alternatives, and many others might be convinced (with more information) of the value of particular alternatives. However, one harbor user expressed his concern that the Corps and the Port might risk investing in an alternative that is not almost guaranteed to reduce shoaling at a reasonable cost when the frustration level among harbor users is so high. It is clear that most people who have participated in the harbor's seemingly endless struggle against shoaling, do not want Santa Cruz Harbor to serve as the "guinea pig" for new experimental alternatives to dredging.

APPENDIX I

The attached is the Santa C.uz Yacht Club's 1992 Racing Schedule. It demonstrates club members ability to use the harbor year round. This year round schedule was not possible before the Seabright dredge operation was in effect. The Club is pleased to be able to schedule winter races.

SCYC 1992 Racing Schedule

Month	Date	Event	Sponsor	Resp. Fleet
January	18	Midwinters #3	SCYC	
February	15	Midwinters #4	SCYC	
	28-01	470 Regatta	SCYC	
March	21	Midwinters #5	SCYC	
April	04	Commodore's Regatta (PHRF (Crewed and DH Divisions)	SCYC	SC-27
	05	Spring SCORE #1	SCYC	
	11	Ano Nuevo Race	MPYC	
	11-12	Spring 505 Open	SCYC	
	25	Spring One Design #1	SCYC	
May	03	Spring SCORE #2	SCYC	J-24
	16	Spring One Design #2	SCYC	
	16-17	MPYC PHRF Invitational	MPYC	
	22	Santa Cruz - Santa Barbara Race	SCYC	
	30-31	Laser NorCal Open	SCYC	
June	07	Spring SCORE #3	SCYC	S-22
	13-14	SC27/Soling Invitational	SCYC	
	20-21	Veeder Cup	SCYC	
	27	Spring One Design #3	SCYC	
July	03	Boreas Race	EYC	SC-40/50
	11	MPYC Singlehanded	MPYC	
	12	Proposed Benefit Regatta	SCYC	
	22-26	Express 27 Nationals	SCYC	
	25	Spring One Design #4	SCYC	
	25	"Hookela" Race	SCYC	
	26	Doublehanded Race	SCYC	
August	01	Spring SCORE #4	SCYC	M-24
	02	Fall SCORE #1	SCYC	
	08-20	505 Worlds	SCYC	
	29	Fall One Design #1	SCYC	
	30	Fall SCORE #2	SCYC	
September	04	Windjammers	SCYC/WYC	
	06	Bang and Go	SCYC	O-25/O-30
	12-13	Plaza Cup	MPYC	
	19	Ladies' Day Regatta	SCYC	
	19	Singlehanded Race	SCYC	
	26	Fall One Design #2	SCYC	
October	03	Jack and Jill Regatta	SCYC	R-23/E-27
	04	Fall SCORE #3	SCYC	
	10-11	Oktoberfest	SBRA	
	17	Fall One Design #3	SCYC	
November	01	Fall SCORE #4	SCYC	Soling
	14	"Champion of Champions" Race	SCYC	
	14	Regatta Awards Ceremony	SCYC	
	21	Midwinters #1	SCYC	
December	19	Midwinters #2	SCYC	

SCYC Regatta Committee/01-16-92

Appendix II

The information in this appendix was provided by the East Cliff Drive Property Owners Association. The association argues that at the time when the harbor was planned and built, the U.S. Army Corps of Engineers recognized the potential problem of "unnatural" cliff erosion which might result from the change in sand movement downcoast caused by the harbor. The Association contends that the Corps of Engineers anticipated the problem which ultimately came to pass (vanishing beaches and cliff erosion), and planned to prevent the problem by implementing a sand bypassing system. Such a bypassing system was not attempted (and it rapidly failed) until long after the downcoast property had been damaged.

The information below includes discussions involving the Corps of Engineers, U.S. Congressman Leon Panetta, and Ed Flavell, President of the East Cliff Drive Property Owners Association, dating from 1958 to 1992 regarding the impact of the harbor on property owners East of the harbor and is intended to support the claims of the Property Owners Association.

EAST CLIFF DRIVE PROPERTY OWNERS ASSOCIATION OF SANTA CRUZ COUNTY

SANTA CRUZ, CALIFORNIA 95060

August 16, 1969

Santa Cruz Port District Commission
135 - 5th Avenue
Santa Cruz, California 95060

Gentlemen:

You will find enclosed a paper prepared within our membership as a result of a motion unanimously passed at our July 29, 1969 meeting. It is entitled "Santa Cruz, California, Small Craft Harbor - A Criticism of Its Management." It has been prepared from reports by the U. S. Army Corps of Engineers and a resolution passed by the Santa Cruz County Board of Supervisors. It proves the case for the Sand bypas plant, which we interpret as an arrangement capable of transferring the day to day accretion west of the harbor to the beach on the east side of the east jetty.

The negligence, of not installing the bypass years ago when conditions required it, has caused much damage to private property. The bypass is more important to many of our people than is the harbor. The damage is being suffered by members of Santa Cruz County who pay all local taxes while many of those who enjoy the use of the harbor come from outside of the county and are taxed only on some purchases they may make in Santa Cruz with but a small part of those taxes being kept by the City or County.

Members of our Association have discussed and corresponded about the erosion problems with both the Yacht Harbor Commission and the U.S. Corps of Engineers. No visible action has been taken and the damage continues.

Our Association is composed of county taxpayers. Prior to taking further action, we will be pleased to have a group we would select from within our membership meet with authoritative representatives of the Santa Cruz Port District Commission together with a (preferably military) representative of the Army Corp of Engineers.

We are aware that the Harbor Commission and Corps plan a meeting during the month of August, 1969 to discuss the planned harbor expansion. Our group feels it is entitled to have at least four members present at that meeting to learn what new plans are being made. We propose further that the matters covered in this letter and report can be discussed with the same, entire group immediately upon conclusion of your meeting.

Will you kindly notify the undersigned as soon as possible concerning our receiving an invitation to the harbor expansion meeting and also advise me if you will agree to the second meeting concerning the sand by pass plant.

Please send copies of your response to Mr. C. N. Gustafson, 2-2790 E. Cliff Drive, and Mr. E. W. Flavell, 2940 Pleasure Point Drive, both in Santa Cruz.

Yours very truly,

Edward J. Warren
President

EJW/dw
Enclosures

Distribution:
U. S. Corps of Engineers,
South Pacific Division
U. S. Corps of Engineers,
San Francisco District
Governor Ronald Reagan
Congressman Talcott
Congressman Gubser
Assemblyman Frank Murphy, Jr.
State Senator Donald Grunsky
Port District Commissioners:
James B. Leask
Donald Starr
John G. Boetger
Ivan C. Ickes
Lee Harris
Port Director L. M. Peterson
City of Capitola:
Mayor John Lappin
City Clerk Ryder Ray
Councilman Frank Beccaria
Councilman Ronald Graves
Councilman Wayne Fontes
Councilman Phillip Walker
Santa Cruz County Supervisors:
Dan D. Forbus
Ralph Sanson
George Cress
Henry Mello
Russ McCallie

EAST CLIFF DRIVE PROPERTY OWNERS ASSOCIATION OF SANTA CRUZ COUNTY
* * * * * * * * * * * * *

Santa Cruz, California Small Craft Harbor - A Criticism of its Management.

Introduction:

1. Absence of sand, cliff erosion, and the extensive scour of beaches as well as their underlying strata has aroused a number of owners of property lying east of the Santa Cruz Harbor, California. Many tens of thousands of dollars have and are being spent to repair seawalls that have fallen as a result of erosion of the solid material on which they were built, and similarly to protect properties where it is evident that damage to dwellings is imminent.

2. On July 27, 1969 a meeting of the East Cliff Drive Property Owners Association of Santa Cruz County took place. Following discussion concerning the absence of the long promised sand bypassing plant at the Santa Cruz Harbor, a motion was carried that a covering letter and report be written to the Santa Cruz Port District Commission reviewing all the evidence concerning the sand bypass available to our group.

3. Adequate evidence existed in March, 1966 to demonstrate the need for the sand bypass at Santa Cruz.

4. Strong feelings were expressed that the Santa Cruz Harbor is being operated solely on the basis of its self interest. Furthermore the occasional sand dredging that has occurred when shoaling sand closed or threatened to close the harbor mouth has not provided adequate amounts of sand to give the protection in continuity or magnitude that existed prior to the construction of the Harbor.

Published Source Material:

5. Studies have been made of the following documents:
March 25, 1958, letter from the Secretary of The Army entitled "Santa Cruz Harbor, California" (1);
November 2, 1965, Resolution No. 801-65 of the Board of Supervisors of Santa Cruz County, California. (2)
March 28, 1966, Department of the Army on the subject "Santa Cruz County Shoreline, California, Section 103 Reconaissance Report for Beach Erosion Control (3).

Proceedure:

6. Exact quotations from the literature cited above are the only facts introduced to develop our conclusions. Quoted passages are identified as to source and source material is attached. Other comments that appear are to provide continuity and draw conclusions.

The Prediction:

7. In paragraph 43 of (1) it states "Pursuant to Section 5 of the River and Harbor Act approved August 30, 1935, an investigation was made to determine the probable effect of the proposed harbor improvements upon the adjacent shoreline." Paragraph 44 of (1) "Summary of Shoreline - effects investigation" gives the conclusions of the investigation. In the interest of simplifying this report we quote only relevant portions below.

8. "The average net annual rate of littoral transport at the harbor site cannot be estimated accurately... The average net rate of downcoast littoral drift may range from 25,000 cubic yards to a possible maximum of 300,000 cubic yards."

9. "If the net annual average rate of downcoast littoral transport approaches the figure of 300,000 cubic yards, erosion would be rapid and

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continuous. Pocket beaches would be denuded and bluff erosion accelerated."

10. "The possible harmful effects of jetty construction could be offset... permanently by providing a means of annually by passing 300,000 cubic yards of littoral material. A sand bypassing plant, therefore should be included as part of the plan of harbor development at Twin Lakes Beach."

11. "The actual volume of littoral drift in transport at the harborsite would become evident soon after construction of the jetties. In the event the rate of drift should be considerably greater or less than anticipated, the method of bypassing could be adjusted to actual conditions. Therefore, construction of the sand bypassing plant should be deferred until its need were demonstrated."

12. The above is official opinion on the part of the U. S. Corps of Engineers, one of the world's most highly recognized authorities in the field of coastal engineering.

QUALITATIVE EVIDENCE OF EROSION RECOGNIZED:

13. Resolution No. 801-65 (2) dated November 2, 1965, two years after construction was started on the west jetty of the Harbor, demonstrates official recognition of the fact that the detrimental effects predicted in reference (1) were indeed occuring. The case is stated so poignently that the entire resolution is included as the next page.

RESOLUTION NO. 801-65

On the motion of Supervisor Black

duly seconded by Supervisor Silliman

the following resolution is adopted:

RESOLUTION OF THE BOARD OF SUPERVISORS OF SANTA CRUZ COUNTY, CALIFORNIA, REQUESTING STUDY OF EROSION CONTROL ON THE SHORE OF MONTEREY BAY BY THE UNITED STATES ARMY CORPS OF ENGINEERS

WHEREAS, sand erosion along the shore of Monterey Bay between the Santa Cruz Yacht Harbor and the westerly limits of the City of Capitola in Santa Cruz County has caused deterioration and destruction of cliff protective structures by wave action, and

WHEREAS, winter storms on Monterey Bay as well as non-storm wave action will cause considerable additional damage to cliffs, and will cause substantial loss of property, and could well cause loss of life unless measures are taken to control erosion immediately.

NOW, THEREFORE, BE IT RESOLVED AND ORDERED by the Board of Supervisors of Santa Cruz County, California, that said Board does hereby request the District Engineer, U. S. Army Engineer District in San Francisco, to conduct a shore and beach restoration and protection study under Section 103 of the 1962 River and Harbor Act, for that portion of Santa Cruz County lying between the Santa Cruz Small Craft Harbor and the westerly limits of the City of Capitola.

PASSED AND ADOPTED by the Board of Supervisors of the County of Santa Cruz, State of California, this 2nd day of November, 1965, by the following vote:

AYES: SUPERVISORS Black Burton, Silliman, Locatelli and McCallie

NOES: SUPERVISORS None

ABSENT: SUPERVISORS None

RUSS McCALLIE
Chairman of said Board

ATTEST: TOM M. KELLEY
Clerk of said Board

DISTRIBUTION: District Engineer, U.S. Army - Senator Grunsky
Governor Brown - Senator Farr
Congressman Talcott - City of Capitola
Assemblyman Po-tee - Public Works
Assemblyman W... on

William H. [illegible]

Incl 1

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14. It should be noted that in line with prediction it was found necessary for the resolution to concern itself only with the area downdrift (east) of the harbor. Furthermore all supervisors were present and all registered aye votes. Particular attention should also be given to the broad distribution of the resolution. In the political sphere it included an elite group of both Federal and state officials as well as public works, which latter would be expected to be made up of technically aware people. The distribution implies that the supervisors considered the matter a serious one and expected the ultimate report to be evaluated by groups representing diverse disciplines.

A Study Made:

15. As a result of County Resolution No. 801-65, the San Francisco District, Corps of Engineers made their Reconaissance Report submitted on March 28, 1966 (2).

16. In paragraph 6 entitled "Existing Corps of Engineers' Projects"
a. Navigation Project: The following statement is made: "The work remaining to be accomplished consists of constructing the sand-bypassing plant. The jetties, channels and basin are under maintenance by the Corps of Engineers."

17. The major conclusions of the Reconaissance Report are summarized below from Table 2 and paragraph 22 of (2).

PRELIMINARY PROJECT COST ESTIMATES

Shore Section and Segment	Estimated First Cost	Estimated Average Annual Costs
Del Mar Beach	$2,405,000.	$325,000.
Opal Cliffs	560,000.	28,000.
Preparation of Reconnaisance report	110,000.	- - -
Totals	$3,075,000	$353,000.

18. Of the above $3,075,000 estimated first cost the Federal government would pay a maximum of $500,000 but only after Santa Cruz County had acquired the entire shore area involved for public use. No members of our Association are aware of anything further being done on the project as proposed. Although the following statement did appear in one letter written by the U.S. Corps San Francisco District Engineer on 30 March 1966, concerning the acquisition of shore area: "Local interests have been advised of this and they have given informal assurances that the County of Santa Cruz would acquire the shore area for public use."

Quantitative Evidence of Littoral Impovrishment:

19. Earlier we quoted from references (1), "If the net annual average rate of downcoast littoral transport approaches the figure of 300,000 cubic yards, erosion would be rapid and continuous. Pocket beaches would be denuded and bluff erosion accelerated."

20. We now quote from paragraph 11 of the Reconaissance Report (2): "Based on information in House Document No. 179 and that developed since construction of the Santa Cruz Harbor jetties, the predominant direction of littoral transport in the area under investigation is to the east and the average annual

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rate of transport is approximately 300,000 cubic yards. Prior to the construction of the jetties, material comprising the littoral transport was quickly moved along the shore by available wave energy .... Thus, if no remedial measures are taken, it can be expected that the cliffs and bluffs located in the study area will erode at a greater rate than what might be called the natural rate."

21. Please note the recurrence of the number 300,000 cubic yards per year. It first appeared as an estimated possible maximum figure. This number did not come off the top of some engineer's head. To appreciate the talent, time, energy and expense that went into its determination, one must read Appendix V of (1) and Appendix II of (4). Consideration was given to littoral material contributed by coastal streams and other means north of the Santa Cruz Harbor site to Pillar Point, a distance of about 70 miles. A 300,000 cubic yard annual littoral drift was later confirmed as a result of beach profile measurements made on the west side of the west harbor jetty by the U.S. Corps of Engineers between November, 1962 and November 1964. During that time the sand volume increased 600,000 cubic yards or 300,000 cubic yards per year. It was remarkable confirmation of a well conceived and well conducted study on the part of the U.S. Corps of Engineers.

The Facts Summarized:

22. A sand bypassing plant would be required at the harbor if the predicted littoral drift approximated 300,000 cubic yards.

23. The Santa Cruz County Supervisors recognized that an erosion problem existed in November of 1965 and stated when they asked for the Reconaissance Report (2) to be made, "... wave action will cause considerable additional damage to cliffs, and will cause substantial loss of property, and could well cause loss of life unless measures are taken to control erosion immediately."

24. As of March 1966 the Corps of Engineers considered the construction of the sand-bypassing plant as work remaining on the original harbor as of March 28, 1966.

25. The Corps of Engineers confirmed that the interruption of littoral drift had indeed averaged 300,000 cubic yards per year over a two year period.

26. The Corps of Engineers stated in paragraph 8 of their Reconaissance Report (2), "No specific plan of improvement has been requested by local interests. Through conferences with local interests, however, it was determined that, in general, local interests desire the most feasible and economic improvements that would prevent further erosion of the shores." In short the Reconaissance Report (2) did not limit Santa Cruz to the $3,075,000 package.

The Question:

27. With the abundance of proof available in November 1965 that shore protection was needed, followed by the confirmation in March 1966 that the maximum estimated littoral drift had indeed been interrupted, and the statement by the U.S. Corps of Engineers that the sand bypass was unfinished business, how could any conscionable representative group arrive at any conclusion other than to install the sand bypass immediately. We can understand how Santa Cruz County with its financial problems would drop a $3,075,000 project plus land acquisition. Particularly when the previous paragraph shows they were not

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limited to this choice We cannot understand how those responsible for running the Santa Cruz Yacht Harbor could overlook the relatively inexpensive alternate of immediately acquiring the sand bypass in 1966. And furthermore they have denied its benefits to their downcoast neighbors in 1967, 1968, and to date in 1969.

The Conclusions:

27. The Santa Cruz Yacht harbor has not been operated with county wide interest as a motive in spite of the interest shown by the County Board of Supervisors as demonstrated in their resolution.

The installation of an operating san bypass plant has been and is an integral part of the 1958 Santa Cruz Harbor project.

* * * * * * * * * * * *

REFERENCES:

1. House Document No. 357 - 85th Congress, 2nd Session, "Santa Cruz Harbor, Calif.", March 25, 1958.

2. Resolution No. 801-65, Resolution of the Board of Supervisors of Santa Cruz County, California, requesting Study of Erosion Control on the Shore of Monterey Bay by The United States Army Corps of Engineers, November 2, 1965.

3. U.S. Army Corps of Engineers - "Santa Cruz County Shoreline, California, Section 103 Reconnaissance Report for Beach Erosion Control", SPNGP, 28 March 1966.

4. House Document No. 179 - 85th Congress, 1st Session, "Santa Cruz County, Calif., Beach Erosion Control Study", May 20, 1957.

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SHORELINE CHANGES

43. *General.*—Pursuant to section 5 of the River and Harbor Act approved August 30, 1935, an investigation was made to determine the probable effect of the proposed harbor improvements upon the adjacent shoreline. Appendix V contains a report of the investigation. Specific studies undertaken included (1) a review of pertinent data contained in the Beach Erosion Control Report on Cooperative Study of Santa Cruz Area dated January 20, 1956, (2) a field and office study of the effects of an experimental barrier groin constructed at Twin Lakes Beach, immediately west of Woods Lagoon, for the purpose of estimating littoral characteristics in the Santa Cruz area, and (3) an investigation of the grain-size characteristics of samples of material that would be dredged in order to form a harbor basin in Woods Lagoon.

44. *Summary of shoreline-effects investigation.*—Conclusions reached in the investigation of the probable shoreline effects of the proposed harbor improvement are:

(*a*) The predominant direction of littoral transport in the Santa Cruz area appears to be downcoast. Reversals in the direction of littoral transport occur at the proposed harbor area, as well as in other areas in Monterey Bay.

(*b*) Erosion that has been occurring in the northern part of Monterey Bay will continue because the alinement of the coast is conducive to a rapid movement of littoral drift out of the area by the available wave energy.

(*c*) The average net annual rate of littoral transport at the harbor site cannot be estimated accurately. The experimental barrier groin did not provide conclusive data on littoral characteristics. Estimates based on shoaling rates at harbors in Monterey Bay and on the sand-producing characteristics of the coastal area upcoast from Twin Lakes Beach indicate that the average net rate of downcoast littoral drift may range from 25,000 cubic yards to a possible maximum of 300,000 cubic yards.

(*d*) Jetties constructed as part of the harbor improvement would form littoral barriers. Such barriers could be expected to benefit the upcoast shores but probably would cause erosion of the shores to the east and south. If the net annual average rate of downcoast littoral transport approaches the figure of 300,000 cubic yards, erosion would be rapid and continuous. Pocket beaches would be denuded and bluff erosion accelerated. The eroding zone would advance quickly to New Brighton Beach State Park and would thereafter progress more slowly to the south as local supply of material became more abundant.

(*e*) The possible harmful effects of jetty construction could be offset initially by depositing sandy material, obtained as a byproduct from dredging of the harbor, on the downcoast beaches and offset permanently by providing a means of annually bypassing 300,000 cubic yards of littoral material. A sand bypassing plant, therefore, should be included as a part of the plan of harbor development at Twin Lakes Beach.

(*f*) Should the net annual rate of littoral drift approach the lower estimated figure of 25,000 cubic yards, the damaging effects of the jetties would be much less pronounced. The initial deposit of material on the downcoast beaches would provide adequate nourishment for an extended period. Under such conditions, a sand bypassing system would not be required. Erosion damage exceeding that now occurring could be prevented by depositing on the beaches material obtained from harbor maintenance dredging.

(*g*) The actual volume of littoral drift in transport at the harbor site would become evident soon after construction of the jetties. In the event the rate of drift should be considerably greater or less than anticipated, the method of bypassing could be adjusted to actual conditions. Therefore, construction of the sand bypassing plant should be deferred until its need were demonstrated.

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
100 McALLISTER STREET
SAN FRANCISCO, CALIFORNIA 94102

IN REPLY REFER TO

SPNGP 28 March 1966

SUBJECT: Santa Cruz County Shoreline, California, Section 103 Reconnaissance Report for Beach Erosion Control

TO: Division Engineer
U. S. Army Engineer Division, South Pacific
San Francisco, California

1. AUTHORITY

This report is submitted in accordance with paragraph 12 of ER 1165-2-13 as the result of a request from the Board of Supervisors of Santa Cruz County, California, to develop a small beach erosion control project along the northerly shore of Monterey Bay under the authority of Section 103a of the 1962 River and Harbor Act. Inclosure 1 is a copy of a resolution dated 2 November 1965 containing the Board of Supervisors request.

2. SCOPE

This report presents a reconnaissance-type analysis of the beach erosion problem for the section of Santa Cruz County shoreline in Monterey Bay, extending from the jettied entrance to Santa Cruz Harbor to the westerly limits of the city of Capitola. The report contains a summary of available data on costs, benefits and economic justification for a prospective small beach erosion project in the reach of shore between Santa Cruz Harbor and Capitola. However, primary consideration for development of a project has been given only to the shore reach extending from Black Point and the westerly city limits of Capitola. The shore segment between the jettied entrance to Santa Cruz Harbor and Black Point is included in an authorized, but uncompleted, shore protection project.

3. DESCRIPTION OF THE AREA

The area considered in this report is located about 75 miles south of San Francisco. The problem area includes about 4.5 miles of the Monterey Bay shoreline of Santa Cruz County and consists of a series

of bluffs ranging from 30 to 75 feet in height. Although there are several short and narrow beaches within the shore reach, the shoreline between the jettied entrance to Santa Cruz Harbor and Capitola is generally rocky. The coastal and upland regions adjacent and north of the shore problem area are part of the Santa Cruz mountains. The principal urban center at the westerly end of the area is the city of Santa Cruz which had a 1960 population of 25,600. Capitola at the eastern end of the area had a 1960 population of 2,000.

4. The shore area under investigation has been developed for recreational and residential use. The State of California, acting through the Department of Parks and Recreation, has developed two beach parks. One of these parks, Twin Lakes Beach, is located in the western end of the study area. The second park, Capitola Beach Park, is located at the eastern end of the area. Except for street ends and sewer-outfall rights-of-way, the shore reach between the two State parks is privately-owned.

5. PRIOR REPORTS

A number of recent Corps of Engineers' reports that contain pertinent data on the area included in this reconnaissance report are listed in Table 1.

TABLE 1

Prior Pertinent Corps of Engineers' Reports

Title, type and date of Chief of Engineers' report	Document No.	Scope and recommendation
San Lorenzo River, Calif.; survey for flood control, 8 December 1953	HD No. 447, 83d Cong., 2d Session	Survey on flood control and allied purposes. Recommended channel improvements including levees and floodwalls
Santa Cruz County, Calif.; cooperative beach erosion control, 26 February 1957	HD No. 179, 85th Cong., 1st Session	Survey on beach erosion control. Recommended riprap seawalls, artifical beach fills and stone groins
Santa Cruz Harbor, Calif.; survey for navigation, 27 February 1958	HD No. 357, 85th Cong., 2d Session	Survey on navigation. Recommended construction of a small-craft harbor including a jettied entrance channel, an inner channel and turning basin

6. EXISTING CORPS OF ENGINEERS' PROJECTS

Two existing Corps of Engineers' projects are located in the study area. One of the projects is a navigation improvement and the other is a beach erosion control and shore-protection project. Each of these projects is described below:

a. Navigation project. The navigation project, authorized by the River and Harbor Act of 1958, provides for a small-boat harbor, named Santa Cruz Harbor, consisting of two jetties, an entrance channel 100 feet wide, 20 feet deep and about 900 feet long, continuing 15 feet deep and the same width for a distance of 370 feet; an inner channel 150 feet wide, 15 feet deep and 800 feet long, continuing 10 feet deep for an additional 600 feet; a turning basin 250 feet wide, 10 feet deep and about 300 feet long; and a sand-bypassing plant. The jetties are of rubble-mound construction; the west jetty being about 1,200 feet long and the east jetty about 810 feet long. The jetties, channels and basin were completed in November 1963 at a total first cost of $2,310,000, of which local interests contributed $810,000. The work remaining to be accomplished consists of constructing the sand-bypassing plant. The jetties, channels and basin are under maintenance by the Corps of Engineers.

b. Beach erosion control project. The beach erosion control project, authorized by the River and Harbor Act of 1958, provides for Federal participation by contribution of funds toward the cost of construction of: (1) a riprap seawall in nine segments, with an aggregate length of about 2,900 feet, along West Cliff Drive; (2) a protective beach with a berm width of 120 feet along the eastern and western segments of Twin Lakes Beach by artificial placement of about 712,000 cubic yards of suitable sand, and two stone groins, one at each of the downcoast (easterly) ends of the two segments; and (3) a riprap seawall about 870 feet in length at Cliff Drive in the vicinity of 49th Avenue in the city of Capitola. All segments of the riprap seawall along West Cliff Drive and about 640 feet of the riprap seawall at Cliff Drive have been completed and are under maintenance by local interests. The entire project is about 28 percent complete. The project work remaining to be completed consists of construction of the protective beach and the stone groin at the easterly segment of Twin Lakes Beach and construction of 230 feet of seawall at Cliff Drive. Because of the accretion of sand that has occurred on the westerly side of the west jetty at Santa Cruz Harbor, it does not appear, at this time (December 1965), that a protective beach will be needed along the entire length of the western segment of Twin Lakes Beach. The latest (1965) approved estimate of cost of new work is $2,290,000, of which about $1,080,000 is the Federal share and $1,200,000 is the non-Federal share. The total first cost of that part of the project completed as of 30 June 1965 is $611,000, of which the Federal Government will contribute approximately $240,000.

7. STATEMENT OF THE PROBLEM

The problem in the area of investigation concerns the erosion by waves and currents of the beaches and cliffs. The erosion, which has been progressive for many years, has possibly been affected by the construction of riprap seawalls along West Cliff Drive and the west jetty at Santa Cruz Harbor in that the seawalls have reduced the amount of beach material being supplied from the bluffs and the west jetty has interrupted the movement of sand along the shore. However, the degree to which erosion has been affected remains to be determined and is, thus, part of the problem.

8. IMPROVEMENTS DESIRED

No specific plan of improvement has been requested by local interests. Through conferences with local interests, however, it was determined that, in general, local interests desire the most feasible and economic improvements that would prevent further erosion of the shore. The coastal reach for which local interests desire protection as a Section 103 project includes a section of shore already a part of a project specifically authorized by Congress. Thus, the shore section, extending from the east jetty at Santa Cruz Harbor to Black Point, is not eligible for financing or construction under Section 103 authority. Therefore, consideration is given only to shore improvements that would protect the shore between Black Point and the westerly limits of Capitola.

9. PHYSICAL FACTORS PERTINENT TO THE PROBLEM

Information and data on physical factors pertinent to the problem are contained in the project document (House Document No. 179, 85th Congress, 1st Session) for the existing beach erosion project in the area under study. Except for the information on littoral transport, the information and data in the project document are still applicable. Preliminary estimates of littoral transport have been developed from incomplete surveys made of the sand accretion upcoast of the west jetty at Santa Cruz Harbor. Surveys made between November 1962, the estimated date when the west jetty first began impounding sand, and November 1964, indicate that the volumetric accretion west of the west jetty amounted to about 600,000 cubic yards. Thus, the average annual rate of littoral transport may approach 300,000 cubic yards.

10. DISPOSAL OF DREDGED MATERIAL

As a means of offsetting possible harmful effects of jetty construction, about 400,000 cubic yards of sandy material, obtained as a byproduct from initial dredging of Santa Cruz Harbor, were deposited on the beach about 1,300 feet downcoast from the jettied entrance channel. Although no quantitative measurements have been made, field inspections

indicate that the greater part of the material so deposited has moved downcoast or easterly. In August 1965, maintenance dredging of the entrance channel was accomplished and 70,000 cubic yards of dredged material were placed on the beach downcoast of the entrance.

11. PRELIMINARY ANALYSIS OF SHORE PROCESSES

Based on the information in House Document No. 179 and that developed since construction of the Santa Cruz Harbor jetties, the predominant direction of littoral transport in the area under investigation is to the east and the average annual rate of transport is approximately 300,000 cubic yards. Prior to the construction of the jetties, material comprising the littoral transport was quickly moved along the shore by available wave energy. Protection of the bluffs along West Cliff Drive and impoundment of littoral drift by the west jetty have probably caused a deficiency of sand along the shore area under study. This deficiency together with the losses from natural shore erosion has produced a critical condition. Thus, if no remedial measures are taken it can be expected that the cliffs and bluffs located in the study area will erode at a greater rate than what might be called the natural rate.

12. METHODS OF CORRECTING PROBLEM CONDITIONS

For convenience in discussing both the shore problems involved and the possible methods of correcting these problems, the shoreline under investigation is divided into two sections as shown on Figure 1 accompanying this report. The first section, extending about 1.1 miles from Black Point to Soquel Point is designated the Del Mar Beach section. The second section, extending about 1.5 miles from Soquel Point to the westerly limits of the city of Capitola, is designated the Opal Cliffs section. Possible methods of correcting shore problems in these two sections are described below.

13. DEL MAR BEACH

The Del Mar Beach section could be protected by construction of an artificial sand beach and four groins; by construction of groins alone; or by construction of riprap seawalls at the critical areas in the section. From the standpoint of beach use, beach fill with groins would be the most satisfactory method. Periodic replacement of the beach fill material would be required to maintain an adequate width of beach. Use of groins alone would probably intensify erosion at other points in or downcoast from the Del Mar Beach section. Riprap walls would maintain a fixed position of the shore but would not prevent erosion of the beach seaward of the walls and high maintenance costs could be expected.

14. OPAL CLIFFS

The Opal Cliffs section could be protected by similar methods to that considered for the Del Mar Beach section. However, the alignment of the Opal Cliffs section and the average direction of wave approach indicate that wave action would cause an artificial beach fill to move rapidly out of the area even if the fill were constructed in conjunction with groins. To stabilize the shore by use of groins alone, a system of closely spaced groins would be required. Such a system would create a sawtooth-shaped shoreline. Critical areas in the Opal Cliffs section could, also, be protected by a riprap wall similar to that constructed as part of the existing shore protection project at Cliff Drive and 49th Avenue in the city of Capitola. Of the possible methods, beach fill and groins would be most satisfactory from the viewpoint of recreational use of the shore area. The absence of beaches under existing conditions indicates beach fill would be expensive to maintain. Use of groins alone might affect the stability of the downcoast beaches. Riprap walls would protect the bluffs against erosion but continued erosion of the area seaward of the walls would result in high maintenance costs.

15. PRELIMINARY PLAN OF IMPROVEMENT

Preliminary analysis of the erosion problem indicates that the following plan of improvement would be suitable:

a. Del Mar Beach section

(1) Beach fill in combination with groins and riprap seawalls.

(2) Riprap seawalls.

b. Opal Cliffs section. Riprap seawalls.

16. DEL MAR BEACH SECTION

In this section the prospective plan of protection, as shown on Figure 1, would provide for a protective beach fill combined with four groins. The protective beach, with an average berm width and height of 120 feet and 12 feet (above mean lower low water, MLLW), respectively, would require about 400,000 cubic yards of sand fill. The stone groins would be constructed with suitable sand-tight cores and with capstone capable of resisting wave forces. The four groins would range in length from 150 feet to 770 feet. The prospective plan would include stone riprap seawalls which would be constructed along the east side of Black Point.

17. Stone riprap seawalls were considered as an alternative to the above described prospective plan. The walls which would have a total

length of about 5,000 feet would be similar to the riprap walls constructed at West Cliff Drive as part of the authorized shore protection project. These seawalls are constructed to an elevation of 17.5 above MLLW and have seaward slopes of 1 on 1-1/2.

18. OPAL CLIFFS SECTION

The prospective plan of improvement for the Opal Cliffs section consists of a riprap seawall, with an aggregate length of about 8,000 feet, constructed along the shore from about 30th Avenue extended to 49th Avenue extended. The seawall would be similar in design to that constructed at Cliff Drive in the city of Capitola. Consideration was given to an alternative plan of beach fill and groins in this section. However, the alternative plan was rejected because preliminary estimates indicate that the plan would be too costly to be economically justified.

19. PRELIMINARY PROJECT COST ESTIMATES

The preliminary estimate of first costs and the annual costs of the prospective projects considered for Del Mar Beach and Opal Cliffs are summarized in Table 2. The preliminary estimate of first costs is based on available information on unit prices in the Santa Cruz area. Annual charges were computed using an interest rate of 3-1/8 percent and an economic life of 50 years. Estimates of annual maintenance of groins and riprap walls are based on district experience with these types of structures. Estimates of the annual beach replenishment quantity are based on an annual rate of loss of fill equal to the estimated annual rate of impoundment by the west jetty at Santa Cruz. This annual quantity would be required for about five years. Thereafter, the sand bypassing plant is expected to be in full and efficient operation and sandy material bypassed and placed on the beach would serve as periodic nourishment.

TABLE 2

Preliminary Project Cost Estimates

Shore Section and Segment	Plan	Estimated first cost	Estimated average annual costs
Del Mar Beach	Beach fill and four groins	$1,900,000	$300,000
	Riprap walls	505,000	25,000
Opal Cliffs	Riprap walls	560,000	28,000

20. PRELIMINARY AVERAGE ANNUAL PROJECT BENEFITS

A preliminary estimate of the average annual benefits that would probably accrue to the prospective projects are summarized in Table 3.

TABLE 3

Prospective Annual Benefits

Shore Section and Plan	Direct Damages prevented 1/	Recreational benefits	Total Benefits
Del Mar Beach			
Beach fill and groins	$18,000	$305,000	$323,000
Riprap walls	18,000	0	18,000
Opal Cliffs			
Riprap walls	28,000	0	28,000

1/ Includes prevention of loss of land, dwellings, utilities and roads.

21. JUSTIFICATION OF PROSPECTIVE PROJECTS

The estimated average annual benefits, annual costs and the resulting benefit-cost ratios for the prospective projects are listed in Table 4.

TABLE 4

Comparison of Annual Benefits and Costs

Shore Section and Plan	Average Annual benefits	Average Annual costs	Benefit-Cost ratio
Del Mar Beach			
Beach fill and groins	$323,000	$300,000	1.1
Riprap seawalls	18,000	25,000	0.7
Opal Cliff			
Riprap seawalls	28,000	28,000	1.0

22. WORK PROGRAM

Preparation of a detailed project report for beach erosion control in the Santa Cruz County shore area considered in this report is estimated to cost $107,000. The estimate of cost for the work program is itemized below:

Preliminary planning and public contracts	$ 1,000
Survey and mapping	25,000
Material and foundation studies	22,000
Design and cost estimates	30,000
Economic studies	2,000
Real estate studies	1,000
Preparation of detailed project report	15,000
Supervision and administration	11,000
Subtotal	$107,000 1/
Preparation of reconnaissance report	$ 2,500 (est.)
Total, rounded	$110,000

1/ Includes $17,000 for preparation of plans and specifications.

23. It is estimated that the detailed project report could be completed within 24 months after receipt of funds and preparation of a work schedule.

24. RECOMMENDATION

The results of the studies made in connection with this reconnaissance report indicate beach erosion control improvements in Santa Cruz County are economically justified and are desired by the County of Santa Cruz Board of Supervisors. The Board of Supervisors has given informal assurances that they would acquire ownership of the privately owned lands. It is recommended, therefore, that authorization be given for preparation of a Detailed Project Report for beach erosion control and that a work allowance of $107,000 be allocated for this purpose under purview of Section 103 of the River and Harbor Act of 1962.

Robert H Allan

ROBERT H. ALLAN
Lt. Colonel, CE
District Engineer

2 Incl
1. Cy of Resolution
2. Proposed Plan of Improvement

RESOLUTION NO. 801-65

On the motion of Supervisor Black
duly seconded by Supervisor Silliman
the following resolution is adopted:

RESOLUTION OF THE BOARD OF SUPERVISORS OF SANTA CRUZ COUNTY, CALIFORNIA, REQUESTING STUDY OF EROSION CONTROL ON THE SHORE OF MONTEREY BAY BY THE UNITED STATES ARMY CORPS OF ENGINEERS

WHEREAS, sand erosion along the shore of Monterey Bay between the Santa Cruz Yacht Harbor and the westerly limits of the City of Capitola in Santa Cruz County has caused deterioration and destruction of cliff protective structures by wave action, and

WHEREAS, winter storms on Monterey Bay as well as non-storm wave action will cause considerable additional damage to cliffs, and will cause substantial loss of property, and could well cause loss of life unless measures are taken to control erosion immediately.

NOW, THEREFORE, BE IT RESOLVED AND ORDERED by the Board of Supervisors of Santa Cruz County, California, that said Board does hereby request the District Engineer, U. S. Army Engineer District in San Francisco, to conduct a shore and beach restoration and protection study under Section 103 of the 1962 River and Harbor Act, for that portion of Santa Cruz County lying between the Santa Cruz Small Craft Harbor and the westerly limits of the City of Capitola.

PASSED AND ADOPTED by the Board of Supervisors of the County of Santa Cruz, State of California, this 2nd day of November, 1965, by the following vote:

AYES: SUPERVISORS Black, Burton, Silliman, Locatelli and McCallie
NOES: SUPERVISORS None
ABSENT: SUPERVISORS None

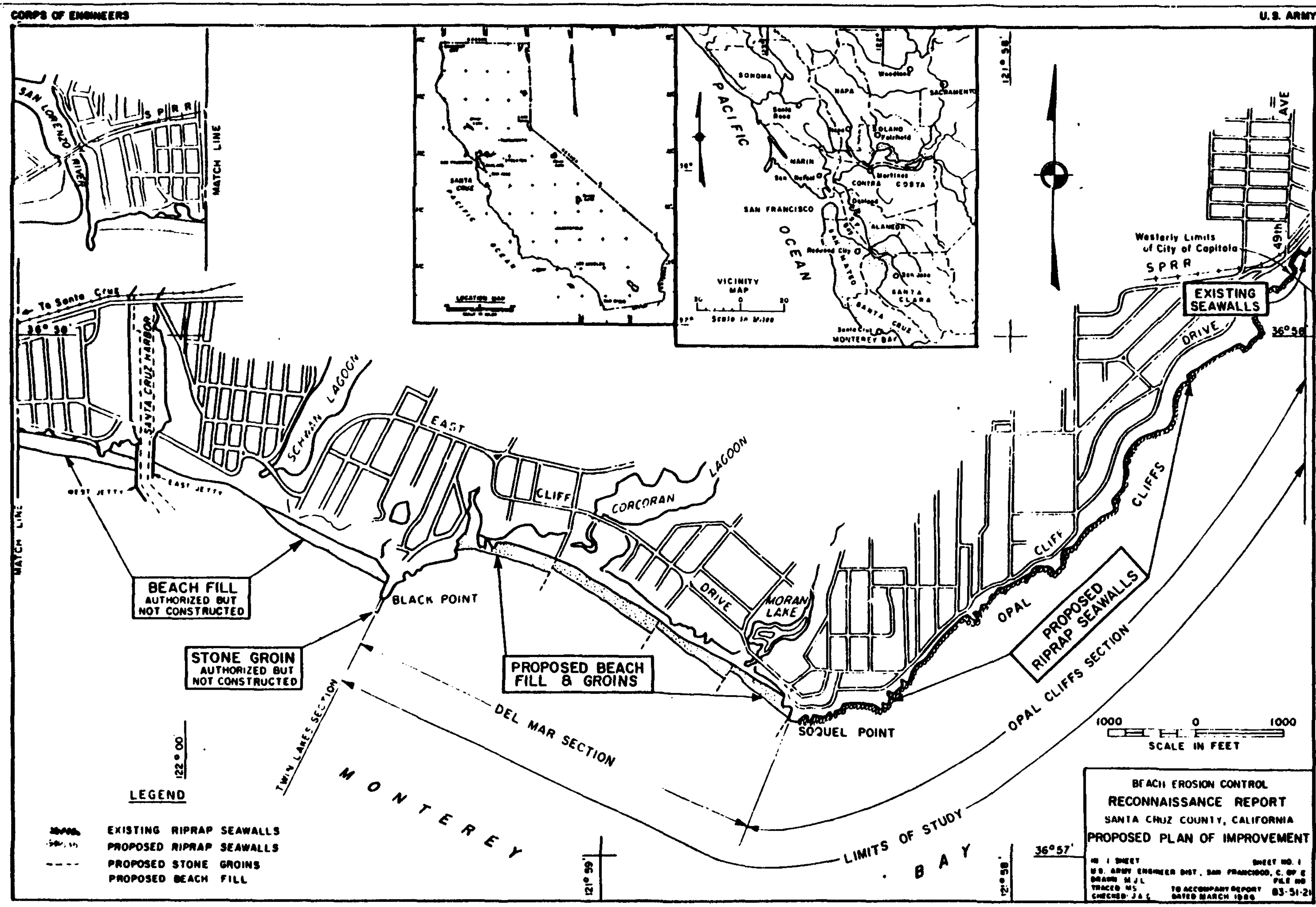
RUSS McCALLIE
Chairman of said Board

ATTEST: TOM M. KELLEY
Clerk of said Board

DISTRIBUTION: District Engineer, U.S. Army - Senator Grunsky
Governor Brown - Senator Farr
Congressman Talcott - City of Capitola
Assemblyman Pattee - Public Works
Assemblyman Wilson

William M. Angel

Incl 1



CORPS OF ENGINEERS
U.S. ARMY
SAN LORENZO RIVER
S P R R
MATCH LINE
To Santa Cruz
36° 58'
SANTA CRUZ HARBOR
WEST JETTY
EAST JETTY
SCHWAN LAGOON
EAST
CLIFF
CORCORAN
LAGOON
DRIVE
MORAN LAKE
BLACK POINT
SOQUEL POINT
OPAL
CLIFF
CLIFFS
DRIVE
EXISTING SEAWALLS
Westerly Limits of City of Capitola
49th AVE
PROPOSED RIPRAP SEAWALLS
PROPOSED BEACH FILL & GROINS
BEACH FILL AUTHORIZED BUT NOT CONSTRUCTED
STONE GROIN AUTHORIZED BUT NOT CONSTRUCTED
TWIN LAKES SECTION
DEL MAR SECTION
OPAL CLIFFS SECTION
LIMITS OF STUDY
MONTEREY BAY
PACIFIC OCEAN
SAN FRANCISCO
SONOMA
NAPA
MARIN
CONTRA COSTA
ALAMEDA
SANTA CLARA
SANTA CRUZ
MONTEREY BAY
VICINITY MAP
Scale in Miles
LOCATION MAP
1000 0 1000
SCALE IN FEET
122° 00'
121° 59'
121° 58'
36° 57'
LEGEND
EXISTING RIPRAP SEAWALLS
PROPOSED RIPRAP SEAWALLS
PROPOSED STONE GROINS
PROPOSED BEACH FILL
BEACH EROSION CONTROL
RECONNAISSANCE REPORT
SANTA CRUZ COUNTY, CALIFORNIA
PROPOSED PLAN OF IMPROVEMENT
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
TO ACCOMPANY REPORT DATED MARCH 1966

STATEMENT BY
COLONEL CHARLES R. ROBERTS, CE
DISTRICT ENGINEER
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
AT CABRILLO, JUNIOR COLLEGE
APTOS, CALIFORNIA
19 AUGUST 1970

EVALUATION OF METHODS
FOR
MAINTENANCE AND SAND BYPASSING FUNCTIONS
AT SANTA CRUZ HARBOR, CALIFORNIA

MY PURPOSE FOR BEING HERE TONIGHT IS TO PRESENT TO YOU A PROPOSAL FOR A SOLUTION OF THE PROBLEM OF SAND BYPASSING AND MAINTENANCE DREDGING AT SANTA CRUZ HARBOR. AS YOU ARE AWARE, THE SANTA CRUZ HARBOR PROJECT WAS AUTHORIZED IN 1958. THE PROJECT CONSISTS OF CONSTRUCTION OF AN ENTRANCE CHANNEL, INNER CHANNEL, TURNING BASIN, EAST AND WEST JETTIES, AND A SAND BYPASSING PLANT. WITH THE EXCEPTION OF THE SAND BYPASSING PLANT, THE PROJECT WAS COMPLETED IN 1963 AND HAS BEEN UNDER MAINTENANCE BY THE CORPS OF ENGINEERS SINCE THAT TIME. CONSTRUCTION OF THE SAND BYPASSING PLANT HAS BEEN DEFERRED UNTIL THE NEED FOR, AND THE TYPE AND CAPACITY OF PLANT COULD BE ESTABLISHED. RESULTS OF STUDIES UNDERTAKEN AT THE TIME OF AUTHORIZATION INDICATED THAT THE PREDOMINANT DIRECTION OF LITTORAL DRIFT WAS TO THE EAST OR DOWNCOAST.

HOWEVER, NEITHER THE ACTUAL RATE OF THE LITTORAL DRIFT AT THE HARBOR SITE NOR THE IMPOUNDING CAPACITY OF THE WEST JETTY COULD BE ACCURATELY PREDICTED AT THAT TIME. IN 1967, MY OFFICE SUBMITTED A REPORT WHICH ESTABLISHED THE NEED FOR CONSTRUCTION OF THE SAND BYPASSING PLANT, AND IN 1968 APPROVAL WAS OBTAINED FROM THE CHIEF OF ENGINEERS FOR A PLAN FOR ACQUISITION OF A 12-INCH HYDRAULIC PIPELINE DREDGE SUBJECT TO THE AVAILABILITY OF FUNDS.

AS A CONDITION OF LOCAL COOPERATION FOR THIS PROJECT, LOCAL INTERESTS ARE TO CONTRIBUTE 35.1 PERCENT OF THE FIRST COST OF THE SAND BYPASSING PLANT. FURTHER CONDITIONS ARE THAT, UPON COMMENCEMENT OF SAND BYPASSING, LOCAL INTERESTS WILL ASSUME THE OPERATION AND MAINTENANCE OF THE SAND BYPASSING PLANT AND MAKE REPLACEMENTS THERETO WHEN AND AS REQUIRED; AND FURTHER MAINTAIN THE DREDGED DEPTHS IN THE ENTRANCE CHANNEL, THE INNER HARBOR CHANNEL, AND THE TURNING BASIN WITH THE UNDERSTANDING THAT THE UNITED STATES WILL REIMBURSE LOCAL INTERESTS FOR THE ACTUAL COST OF PLANT OPERATION, MAINTENANCE, AND REPLACEMENT UP TO A LIMIT OF $35,000 ANNUALLY. WITH THE ACTUAL ACQUISITION OF BYPASSING EQUIPMENT BEING IMMINENT, MY OFFICE HAS UNDERTAKEN INVESTIGATION OF SEVERAL METHODS OF

SAND BYPASSING IN ORDER TO ASSURE THAT THE MOST FEASIBLE AND ECONOMICAL SYSTEM WOULD BE UTILIZED. THE FOUR BASIC PLANS CONSIDERED IN THIS STUDY WERE (1) A RAIL-MOUNTED DREDGE LOCATED ON THE WEST JETTY; (2) CABLEWAY BUCKETS; (3) SUBMERGED FIX SUCTION PIPELINE; AND LASTLY (4) A 12-INCH HYDRAULIC PIPELINE DREDGE.

ONE OF THE BASIC CONSIDERATIONS IN THE DESIGN OF ANY SAND BYPASSING EQUIPMENT IS THE REQUIRED CAPACITY FOR MOVING THE MATERIAL. OUR EXPERIENCE WITH MAINTENANCE DREDGING TO DATE HAS BEEN THAT WE HAVE BEEN REMOVING APPROXIMATELY 70 TO 80 THOUSAND CUBIC YARDS ANNUALLY. EXPERIENCE WITH ACCRETION IN THE APPROACH CHANNEL SHOWS THAT THE CHANNEL SUFFERS SEVERE SHOALING IN LATE WINTER AND EARLY SPRING, WHICH AT TIMES HAS RESULTED IN COMPLETE CLOSING OF THE HARBOR TO NAVIGATION EXCEPT AT HIGH TIDE. THIS MAP INDICATES THE SHOALING PATTERN AFTER OUR DREDGING IN 1969 UNTIL (*DISPLAY) MAY OF THIS CURRENT YEAR. YOU WILL NOTE THAT IT INDICATES AN AMOUNT OF SHOALING OF 24 FEET AT THE DOGLEG AREA. OUR EXPERIENCE HAS BEEN THAT SHOALING FIRST OCCURS ON THE INSIDE OF THE WEST JETTY, PARTICULARLY AT THE INSIDE OF THE DOGLEG AND ALSO IS A POINT OF MAXIMUM SHOALING. THE RAPIDITY OF SHOALING WOULD SEEM TO INDICATE THAT THE MAXIMUM CAPACITY OF THE CHANNEL SERVING AS A HOLDING BASIN IS REACHED DURING A

SINGLE SEVERE STORM OR A SHORT PERIOD OF STORM ACTIVITY. SHOULD THESE BASINS BE PERIODICALLY RELIEVED BY A SAND BYPASSING SYSTEM, THE AMOUNT OF MATERIAL TO BE REMOVED WOULD THEREFORE GREATLY EXCEED THE PHYSICAL STORAGE CAPACITY. THE AMOUNT OF MATERIAL TO BE BYPASSED ON AN ANNUAL BASIS WOULD THEREFORE BE MUCH GREATER THAN THE MAINTENANCE DREDGING HISTORY WOULD INDICATE. IN ADDITION, RESTRICTIONS AS TO THE TIME AND DURATION OF DEPOSITION OF THE MATERIAL ON THE DOWNCOAST BEACHES REQUIRE REMOVAL OF A GREATER AMOUNT OF MATERIAL IN A SHORT PERIOD. THE RESTRICTION ON PUMPING MATERIAL ON THESE DOWNCOAST BEACHES GENERALLY RUNS BETWEEN MID-MAY AND MID-OCTOBER IN ORDER TO RESERVE THESE BEACHES FOR RECREATIONAL PURPOSES.

IN ORDER TO MAINTAIN THE CAPACITY IN THE APPROACH CHANNELS SERVING AS STORAGE BASINS AND PREVENT CLOSING THE HARBOR TO NAVIGATION, A BYPASS CAPACITY OF TWICE THE CAPACITY OF THE STORAGE BASINS OR APPROXIMATELY 200,000 CUBIC YARDS DURING THE RESTRICTED PERIOD IS CONSIDERED NECESSARY. IN ADDITION, THE PLANT SHOULD HAVE A CAPACITY OF 300,000 CUBIC YARDS ANNUALLY WHICH IS EQUAL TO THE ASSUMED RATE OF MOVEMENT WHICH WAS ESTABLISHED IMMEDIATELY FOLLOWING THE CONSTRUCTION OF THE JETTIES, WHEN APPROXIMATELY 600,000 CUBIC YARDS OF SAND WERE

DEPOSITED ON THE UPCOAST BEACHES IN A PERIOD OF 2 YEARS. SINCE THAT TIME THE UPCOAST BEACH HAS BEEN ESSENTIALLY STABLE WITH RELATIVELY MINOR SEASONAL VARIATIONS.

THE RAIL-MOUNTED DREDGE SYSTEM BEING CONSIDERED IS AN ADAPTION OF (*DISPLAY) A SYSTEM WHICH IS BEING INSTALLED IN CAPE CANAVERAL, FLORIDA. THE ADAPTED SYSTEM WOULD CONSIST OF A DREDGE MOUNTED ON RAILS ON THE WEST JETTY TO PROVIDE MOBILITY AND TO EXTEND THE FULL LENGTH OF THE JETTY. THE DREDGE PUMP WOULD BE MOUNTED ON ONE END OF A STRUCTURAL STEEL LADDER SO THAT IT COULD BE SWUNG ON THE CHANNEL SIDE OR ALSO INTO THE UPCOAST AREA. THE PUMP WOULD BE SIZED TO REMOVE 200,000 CUBIC YARDS OF MATERIAL WITHIN OUR OPERATING TIME AND THE MATERIAL WOULD BE DISPOSED OF DOWNCOAST ON THE BEACHES BY PIPELINE. THE LIMITATION OF THIS EQUIPMENT IS THAT THE REACH OF THE DREDGE PUMP IS, OPTIMISTICALLY, A MAXIMUM OF 100 FEET. THUS THE PURPOSE OF BYPASSING THE SAND WOULD BE FULFILLED. HOWEVER, IT WOULD NOT BE POSSIBLE TO MAINTAIN THE PROJECT CHANNELS BY USE OF THIS EQUIPMENT AND AUXILIARY EQUIPMENT WOULD BE REQUIRED TO MAINTAIN THE CHANNEL AND TURNING BASIN. THIS EQUIPMENT COULD BE OTHER SYSTEMS WHICH OPERATE IN THE CHANNEL SUCH AS A HYDRAULIC DREDGE.

THE SECOND SYSTEM CONSIDERED IS AN ADAPTATION OF COMMERCIAL RECOVERY (*DISPLAY) OPERATIONS WHICH WE

DESIGNATE AS CABLEWAY BUCKETS. THIS CONSISTS OF A RAIL-MOUNTED OPERATING PLATFORM MOUNTED ON THE WEST JETTY AT ONE POSITION OPERATING THROUGH CABLE SYSTEMS TO ANCHORS LOCATED OUTSIDE THE ENTRANCE IN LINE WITH THE CENTERLINE OF CHANNEL. THUS, THIS SYSTEM WOULD REMOVE MATERIAL FROM THE OUTER ENTRANCE CHANNEL. A SECONDARY SYSTEM WOULD BE THE CONSTRUCTION OF A SANDTRAP OUTBOARD OF THE WEST JETTY. THIS ALSO WOULD HAVE TO HAVE BRIDLES MOUNTED ON SUBMERGED ANCHORS LOCATED OUTBOARD. SUB-MERGED ANCHORS ARE REQUIRED FOR THE BRIDLE CABLES IN ORDER TO REMOVE A HAZARD TO NAVIGATION WHICH WOULD BE IN EXISTENCE THROUGH INSTALLATION OF NORMAL ANCHOR TOWERS. IN ADDITION, THE HEIGHT OF THE SKID FRAME HAS BEEN REDUCED TO ABOUT 25 TO 30 FEET IN HEIGHT IN ORDER TO AVOID VISUAL POLLUTION. THE COMBINATION OF THESE TWO FEATURES HAS RESULTED IN THE INABILITY OF THE PLANT TO DEPOSIT MATERIAL EXCEPT ALONG THE INSIDE OF THE WEST JETTY OR THE OUTSIDE OF THE WEST JETTY WHEN WORKING IN THE STORAGE BASIN AREA. IN ORDER TO REMOVE THE MATERIAL FROM THESE STOCKPILE AREAS AND DISPOSE OF IT DOWNCOAST ON THE BEACHES, AUXILIARY EQUIPMENT WOULD BE NEEDED. THIS EQUIPMENT COULD CONSIST OF THE RAIL-MOUNTED DREDGE PREVIOUSLY DESCRIBED OR A HYDRAULIC DREDGE OPERATION. IN ADDITION, THIS EQUIPMENT WOULD NOT PROVIDE FOR A MAINTENANCE OF THE

INNER CHANNEL OR TURNING BASIN AND AUXILIARY EQUIPMENT OR CONTRACTS WOULD BE REQUIRED FOR THIS PURPOSE.

THE THIRD SYSTEM CONSIDERED WAS A SUBMERGED FIXED SUCTION PIPELINE. (*DISPLAY) SEVERAL INSTALLATIONS OF THIS TYPE HAVE BEEN MADE THROUGHOUT THE COUNTRY. HOWEVER, THE SYSTEM WE HAVE CONSIDERED HERE IS A PROPRIETARY SYSTEM CURRENTLY UNDER DEVELOPMENT BY A PRIVATE CORPORATION. THE UNIQUE FEATURE IS A SELF PRIMING SYSTEM WHICH PURPORTS TO ALLOW STARTUP REGARDLESS OF THE DEPTH OF SUBMERSION IN THE SAND. THIS HAS BEEN ONE OF THE MAJOR DRAWBACKS OF THE INSTALLATION OF THIS TYPE OF SYSTEM HERETOFORE. THE PIPE WOULD BE INSTALLED AT A DEPTH TO MAINTAIN THE CHANNEL DEPTH AND WIDTH THROUGH FREEFLOW OF MATERIAL TO THE INTAKES. A PUMPING PLANT WOULD BE INSTALLED ON THE EAST JETTY WITH DISCHARGE TO THE SPOIL AREAS THROUGH THE PIPELINE TO THE FORESHORE ZONE OF THE BEACH DOWNCOAST OF THE EAST JETTY. AT PRESENT THIS SYSTEM IS NOT OPERATIONAL AND DIFFICULTIES HAVE BEEN ENCOUNTERED IN INSTALLATION OF THE SYSTEM. THEREFORE, THIS IS NOT A PROVEN PRODUCT AND WOULD REPRESENT AN ELEMENT OF RISK. IN ADDITION, A MAJOR DRAWBACK TO THIS TYPE OF EQUIPMENT IS THE FACT THAT IT IS OF LIMITED LIFE WITH WEAR ON THE PIPELINE AND PUMPING PLANT BEING EXPECTED TO RESULT IN THE NEED FOR REPLACEMENT IN APPROXIMATELY 10 YEARS. AS YOU WILL NOTE, THE LIMITED REACH OF THE SYSTEM WILL ALSO REQUIRE AUXILIARY EQUIPMENT TO MAINTAIN

THE INNER CHANNEL AND BASIN.

THUS, WE RETURN TO THE FOURTH SYSTEM OR THE HYDRAULIC PIPELINE DREDGE SYSTEM. THE USE OF THE HYDRAULIC DREDGE HAS BEEN PROVEN TO BE SUCCESSFUL IN REMOVAL OF MATERIAL IN THE ENTRANCE CHANNEL AND THE TURNING BASIN AND DISPOSITION OF THE SPOILS IN THE DOWNCOAST BEACH FOR RETURN TO THE LITTORAL DRIFT REGIME. THE LIMITATIONS FOR WORK HAVE BEEN A LIMITATION ON AVAILABLE TIME TO ACCOMPLISH THE WORK BY CONTRACT. THE STATIONING OF A DREDGE IN THE HARBOR WOULD ASSURE AVAILABILITY AT ALL TIMES, SINCE DURING THE STORM SEASON MANY PERIODS OCCUR DURING WHICH DREDGING COULD BE ACCOMPLISHED. IT WOULD BE POSSIBLE TO ASSURE THAT THE CHANNEL SHOALING COULD BE REMOVED AS IT OCCURS, THEREFORE MAINTAINING THE CHANNEL IN A NAVIGABLE CONDITION. SHOULD ANY UNUSUALLY SEVERE STORM CLOSE THE CHANNEL, THE DREDGE WOULD BE AVAILABLE FOR IMMEDIATE OPENING OF THE CHANNEL WITHOUT ABNORMAL DELAY AWAITING CONTRACT OPERATIONS. IN ADDITION, THE PLANT WOULD BE AVAILABLE FOR MAINTENANCE OF THE INNER CHANNELS AND TURNING BASIN.

ALL OF THE SYSTEMS CONSIDERED ARE ASSUMED TO BE CAPABLE OF BYPASSING SAND TO THE DOWNCOAST BEACH DISPOSAL AREA AND THUS SATISFYING THE REQUIREMENT OF THE PROJECT FOR THIS PURPOSE. HOWEVER, THE FIRST THREE SYSTEMS ARE UNABLE TO COMPLETELY MAINTAIN THE PROJECT CHANNELS AS IS ALSO A REQUIREMENT OF THE PROJECT AND SECONDARY OR AUXILIARY EQUIPMENT IS REQUIRED. THE MOST SATISFACTORY

AND VERSATILE AUXILIARY EQUIPMENT WOULD BE A HYDRAULIC DREDGE CAPABLE OF MAINTAINING INNER CHANNEL AND TURNING BASIN AS WELL AS SUPPLEMENTING THE BYPASS SYSTEM SELECTED. THE FIRST THREE SYSTEMS CONSIDERED ARE ACTUALLY MULTIPLE SYSTEMS HAVING REPETITIVE USE OF VARIOUS TYPES OF EQUIPMENT AND ACTUALLY REQUIRING USE OF THE FOURTH SYSTEM TO SATISFACTORILY PERFORM THEIR FUNCTION. IT IS THEREFORE OBVIOUS THAT THE USE OF A HYDRAULIC DREDGE DESIGNED TO PERFORM THE MAINTENANCE AND THE BYPASS OPERATION WOULD BE THE MOST ECONOMICAL AND SATISFACTORY SOLUTION.

THE ACTUAL PROCEDURE TO BE FOLLOWED IN MAINTAINING THE CHANNEL AND BYPASSING SAND TO THE DOWNCOAST BEACHES CAN BE DETERMINED BEST BY ACTUAL OPERATION. HOWEVER, A POSSIBLE PROCEDURE IS OUTLINED HERE IN ORDER TO ESTABLISH A POINT OF REFERENCE. DREDGING OPERATIONS WOULD NOT BE PERFORMED BETWEEN 15 MAY AND 15 OCTOBER BECAUSE OF THE INADVISABILITY OF USING THE BEACH AREAS FOR DISPOSAL OF MATERIAL DURING THE RECREATION SEASON, AND IN ORDER TO PERMIT FULL USE OF THE HARBOR AND CHANNEL BY BOATING INTERESTS. THEREFORE, IN ORDER TO PREPARE THE CHANNEL TO SERVE AS A STORAGE BASIN, DREDGING WOULD BE PERFORMED IN NOVEMBER AND DECEMBER TO FULL PROJECT DEPTHS. DURING THE WINTER STORM SEASON DREDGING WOULD BE PERFORMED AS CALM WEATHER IS AVAILABLE TO BYPASS SAND AND ASSURE THE

MAINTENANCE OF THE STORAGE CAPACITY OF THE CHANNEL. THEREFORE, FOLLOWING THE STORM SEASON, THE LAST DREDGING OPERATION WOULD BE PERFORMED IN APRIL AND MAY TO BYPASS SAND AND TO RESTORE THE CHANNEL TO FULL CAPACITY FOR THE APPROACHING RECREATIONAL SEASON. IT IS ESTIMATED THAT APPROXIMATELY 200,000 CUBIC YARDS OF SAND WOULD BE BYPASSED USING THIS PROCEDURE. ON THE RARE OCCASION WHEN UNUSUAL WINTER ACTIVITY DEPOSITS AN UNUSUAL AMOUNT OF MATERIAL IN THE CHANNEL, THE CHANNEL MIGHT BE CLOSED TO NAVIGATION. HOWEVER, THE READY AVAILABILITY OF THE DREDGE WOULD ENABLE THE CHANNEL TO BE CLEARED AND SAND BYPASSED QUICKLY IN EVENT OF THIS OCCURRENCE.

PENDING THE OUTCOME OF THIS PRESENTATION, NO DETAILED DESIGN WORK HAS BEEN DONE ON A DREDGE. HOWEVER, IT IS DETERMINED THAT, BASED ON THE REQUIRED CAPACITY, THERE IS A REQUIRED PRODUCTION OF ABOUT 155 CUBIC YARDS PER HOUR. THIS REQUIRES A 600-HORSEPOWER DIESEL ELECTRIC ENGINE FOR THE MAIN PUMP TO DISPOSE OF THE DREDGE MATERIAL ON TWIN LAKE BEACH. DUE TO THE OCCURRENCE OF KELP RAFTS IN THE CHANNEL LAST YEAR, IT HAS BEEN DETERMINED THAT A CUTTERHEAD SHOULD BE PROVIDED IN ORDER TO ASSURE THE PROPER DISPOSITION OF THIS TYPE OF MATERIAL. THIS CUTTERHEAD WOULD BE PROVIDED WITH APPROXIMATELY 125-HORSEPOWER MOTOR. A LADDER OF APPROXIMATELY 40-FOOT

LENGTH WOULD BE REQUIRED TO DREDGE THE 20-FOOT CHANNEL DEPTH WITH AN ALLOWANCE FOR SURGES AND SWELLS. ALL THIS DREDGING MACHINERY WOULD BE MOUNTED ON AN 80-FOOT-LONG BARGE WITH A 30-FOOT BEAM AND DRAFT OF APPROXIMATELY 5 FEET. THE BARGE WOULD BE EQUIPPED WITH SPUDS FOR OPERATION IN CALM WEATHER AND WINCHES, WIREROPES, AND ANCHORS FOR USE IN MORE EXPOSED LOCATIONS. A DREDGE TENDER IS REQUIRED TO PROVIDE FOR MOVING THE DREDGE FOR SETTING ANCHORS AND FOR SERVICING THE DREDGE. BOTH FLOATING AND LAND PIPELINE IS REQUIRED IN ORDER TO REACH THE DISPOSAL AREA. THE HANDLING OF THIS PIPELINE COULD READILY BE PROVIDED BY CONTRACT OR ON A RENTAL BASIS.

THUS, OUR STUDY INDICATES THAT OF THE FOUR SYSTEMS ONLY ONE FULLY SATISFIES ALL CONDITIONS OF THE PROJECT, AND IT IS THEREFORE PROPOSED THAT A 12-INCH CUTTERHEAD HYDRAULIC PIPELINE DREDGE BE PROVIDED FOR SAND BYPASSING AND MAINTENANCE OF CHANNELS AT SANTA CRUZ HARBOR. THE ESTIMATED FIRST COST OF THE DREDGE SYSTEM INCLUDING ALL GOVERNMENT COSTS FOR ENGINEERING AND ACQUISITION IS IN THE ORDER OF $550,000.

IN REGARD TO THE OPERATION AND MAINTENANCE OF THE SYSTEM, THE CONDITION OF LOCAL COOPERATION WHICH STIPULATES THAT THE FEDERAL GOVERNMENT WILL REIMBURSE LOCAL INTERESTS

TO THE MAXIMUM AMOUNT OF $35,000 ANNUALLY FOR MAINTENANCE OF THE CHANNELS IS TO BE RESTUDIED BY MY OFFICE. IN VIEW OF THE LENGTH OF TIME THAT HAS PASSED SINCE ESTABLISHMENT OF THIS FIRM AMOUNT AND OUR EXPERIENCE IN DREDGING IN THE HARBOR SINCE THAT TIME, I WISH TO INVESTIGATE THE POSSIBILITY OF AN INCREASE IN THE AMOUNT DUE BOTH TO PRICE LEVEL INCREASE AND AMOUNT OF MATERIAL REMOVED ANNUALLY AND I WILL ACTIVELY PURSUE THIS INVESTIGATION.

THE STATEMENT THAT FOLLOWS WAS MADE
AT AN ADJOURNED SPECIAL MEETING OF THE
SANTA CRUZ PORT DISTRICT COMMISSION
THURSDAY, SEPTEMBER 7, 1972 AT
CABRILLO COLLEGE GYMNASIUM
APTOS, CALIFORNIA

MR. HARRIS, OTHER PORT DISTRICT BOARD MEMBERS, LES PETERSON, LADIES AND GENTLEMEN:

MY NAME IS ED FLAVELL. I AM PRESIDENT OF THE EAST CLIFF DRIVE PROPERTY OWNERS ASSOCIATION. OUR PROPERTY IS LOCATED AT 2940 PLEASURE POINT DRIVE, SANTA CRUZ.

WASN'T IT A GREAT FILM* THAT WE JUST SAW? THOSE WHO MADE IT DID A FINE JOB OF SIMPLIFYING A COMPLEX SUBJECT.

SINCE WE ALL HAVE IT FRESH IN OUR MINDS, IT SEEMS TO BE APPROPRIATE TO DISCUSS THE RIVER OF SAND AS IT PERTAINS TO OWNERS OF SHORELINE PROPERTY EAST OF THE SANTA CRUZ HARBOR AS WELL AS TO HARBOR OPERATIONS.

MEMBERS OF OUR ORGANIZATION AND I HAVE SIGNED THE PETITION URGING THE CORPS OF ENGINEERS TO INITIATE A MAINTENANCE DREDGING SCHEDULE THAT WILL KEEP THE CHANNEL OPEN AND SAFE ON A YEAR-AROUND BASIS. SO DOING, HOWEVER, WILL NOT NECESSARILY PROVIDE US WITH THE AMOUNT OF SAND WE NEED TO AVOID EXCESSIVE SHORELINE EROSION.

*THE BEACH - A RIVER OF SAND: AGI-EDF EARTH SCIENCE SERIES PRODUCED BY ENCYCLOPAEDIA BRITANNICA.

THIS WINTER AND SPRING HAVE BEEN PART OF A GOOD SAND YEAR FOR US TO THE EAST OF THE HARBOR BECAUSE THE HARBOR WAS SHOALED SHUT FOR MANY MONTHS. DURING THAT TIME THE RIVER OF SAND WAS FLOWING PAST THE HARBOR AND PAST OUR PROPERTIES, SO WE HAD SAND DURING THOSE MONTHS OF HIGH TRANSPORT ENERGY IN THE LITTORAL ZONE.

YOU SAW IN THE FILM HOW PATCHES OF YELLOW DYE MOVED RAPIDLY PARALLEL TO THE SHORELINE IN THE SHALLOW SURF ZONE BUT HARDLY MOVED WHEN JUST BEYOND THE BREAKERS. WHEN THE MOUTH OF OUR HARBOR IS OPEN, BECAUSE OF ITS DEPTH THE SAND RUNS INTO IT RATHER THAN PAST IT.

HOW FAST THE SAND RUNS INTO THE APPROACH CHANNELS SERVING AS STORAGE BASINS, DEPENDS UPON THE AVAILABLE WAVE ENERGY. WHEN THE MOVEMENT INTO THE HARBOR IS HEAVY, THAT IS PRECISELY THE TIME WHEN WE NEED TO HAVE THE SAND BYPASSED BECAUSE THEN IS WHEN THAT SAME WAVE ENERGY IS SCOURING OUR SHORE LINE MOST RAPIDLY.

EACH TIME THE HARBOR FILLS, THE MOVEMENT OF 70 TO 80,000 CUBIC YARDS OF SAND HAS BEEN DENIED TO THOSE OF US WHO LIVE TO THE EAST OF THE HARBOR. THAT IS ABOUT ONE-FOURTH OF A YEAR'S SUPPLY. WHILE IT ACCUMULATES IN THE HARBOR, WE HAVE EXCESSIVE EROSION.

AS THE FORMER PRESIDENT OF OUR ORGANIZATION ONCE PUT IT IN A LETTER TO THE SAN FRANCISCO DISTRICT ENGINEER: "WE NOW RECEIVE SAND ONCE A YEAR WHEN THEY DREDGE THE HARBOR IN MARCH AND APRIL. WE HAVE NOT RECEIVED SAND ON A REGULAR BASIS AS WAS NATURE'S WAY BEFORE THE YACHT HARBOR. THIS IS SIMILAR TO THE DELIVERY OF MILK....IT IS ESSENTIAL TO GET IT DAILY, NOT A TRUCK-LOAD ONCE A YEAR."

OUT OF FAIRNESS TO OUR SITUATION DOWN COAST, WE HAVE TO QUESTION WHETHER WE WILL HAVE ADEQUATE PROTECTIVE SAND IF THE HARBOR IS DREDGED TWO OR EVEN THREE TIMES A YEAR. AFTER ALL, IT WAS ACCUMULATING WHEN WE NEEDED IT MOST. IT IS STILL OUR FEELING THAT A SYSTEM APPROACHING CONTINUOUS BYPASSING OF SAND IS THE ANSWER TO BOTH THE SHOALING PROBLEM AT THE HARBOR AND OUR ACCELERATED EROSION PROBLEM.

LES PETERSON VERY KINDLY GAVE ME A COPY OF A LETTER WRITTEN AUGUST 1, 1972 TO HIM BY COL. J. L. LAMMIE, SAN FRANCISCO DISTRICT ENGINEER OF THE U. S. ARMY CORPS OF ENGINEERS. IT READS AS FOLLOWS:

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
100 McALLISTER STREET
SAN FRANCISCO, CALIFORNIA 94102

REPLY TO
ATTENTION OF: SPNDE

1 August 1972

Mr. Lester M. Peterson
Port Director
Santa Cruz Port District
135 - 5th Avenue
Santa Cruz, California 95060

Dear Mr. Peterson:

As Colonel Mixan discussed with you by phone, our Division Engineer has recommended the following procedures to satisfy the dredging maintenance needs at Santa Cruz Harbor.

a. First, we plan to withdraw the dredge Santa Cruz from the harbor for transfer to an area appropriate to its design.

b. Second, Santa Cruz Port District will be reimbursed for expenses incurred in maintenance and repair of the dredge.

c. Third, interim maintenance of Santa Cruz Harbor will be resumed by the Federal Government through the former system of late spring dredging.

d. Fourth, a review of the sand-bypassing requirement at Santa Cruz Harbor will be conducted by the San Francisco District.

Sincerely yours,

J. L. LAMMIE
Colonel, CE
District Engineer

WE IN OUR ASSOCIATION TAKE EXCEPTION TO THE THIRD AND FOURTH POINTS. THE DIVISION ENGINEER IS SIMPLY RETURNING US TO A SITUATION THAT HAS BEEN UNTENABLE DURING THE ENTIRE LIFE OF THE PORT FACILITY: NAMELY, ANNUAL DREDGING AND STUDY OF BYPASSING REQUIREMENTS. IT APPEARS TO BE AN EXCUSE FOR AVOIDING POSITIVE ACTION.

THE BYPASSING REQUIREMENT WAS STUDIED BY THE SAN FRANCISCO DISTRICT AND REPORTED HERE AT CABRILLO COLLEGE ON AUGUST 19, 1970 BY COL. CHARLES R. ROBERTS, WHO WAS THEN DISTRICT ENGINEER. WE INVITE COL. LAMMIE TO REFER TO COL. ROBERTS' REPORT AND FIND THE STATEMENT THAT "....THE PLANT SHOULD HAVE A CAPACITY OF 300,000 CUBIC YARDS ANNUALLY WHICH IS EQUAL TO THE ASSUMED RATE OF MOVEMENT WHICH WAS ESTABLISHED IMMEDIATELY FOLLOWING CONSTRUCTION OF THE JETTIES." IT HAD BEEN DESCRIBED EARLIER IN THE SAN FRANCISCO DISTRICT ENGINEER'S "SANTA CRUZ COUNTY SHORELINE, SECTION 103, RECONNAISSANCE REPORT FOR BEACH EROSION CONTROL". THE COLLAPSE OF MANY SEAWALLS AND THE DISAPPEARANCE OF CAPITOLA BEACH LED THE SANTA CRUZ COUNTY BOARD OF SUPERVISORS ON NOVEMBER 2, 1965 TO PASS THEIR RESOLUTION 801-65 REQUESTING THIS REPORT. INCIDENTALLY, CONCERNING THE SANTA CRUZ HARBOR, IT WAS STATED IN THAT RECONNAISSANCE REPORT SIX YEARS AGO THAT, "THE WORK REMAINING TO BE

ACCOMPLISHED CONSISTS OF CONSTRUCTING THE SAND BYPASSING PLANT. THE JETTIES, CHANNELS AND BASIN ARE UNDER MAINTENANCE BY THE CORPS OF ENGINEERS." HOW CAN MORE STUDY CONCERNING THE BYPASSING REQUIREMENT BE CONSCIONABLY PROPOSED?

WE ALL KNOW THE HISTORY OF THE DREDGE "SANTA CRUZ". IT IS A FLAGRANT CASE OF MONUMENTAL INEPTITUDE. OUR PORT DISTRICT PEOPLE WERE GIVEN NO SAY IN THE DESIGN, CONSTRUCTION, OR ACCEPTANCE OF THE DREDGE. THEY HAD NO ACTIVE ROLE IN SPITE OF $160,000 OF LOCAL MONEY BEING INVOLVED. FURTHERMORE, COMPETENT COUNSEL FROM EARL & WRIGHT, THE ENGINEERS WHO DESIGNED THE HARBOR, WAS IGNORED.

BYPASSING REQUIREMENTS HAVE NOT CHANGED SINCE COL. ROBERTS MADE HIS REPORT. THE PROBLEM IS THE SAME AND ITS POSSIBLE SOLUTIONS DIFFER ONLY IN DETAIL. PROVIDING THE SANTA CRUZ HARBOR WITH A FLOATING HYDRAULIC DREDGE WAS NOT BAD IN CONCEPT; THE FAILURE WAS IN EXECUTION.

IN OUR OPINION WHAT WE NEED IMMEDIATELY IS EITHER AN ALL WEATHER LAND BASED BYPASSING PLANT WORKING ALONG THE WEST JETTY OF THE HARBOR PLUS, IF IT IS NEEDED, MAINTENANCE DREDGING BY THE CORPS OF ENGINEERS; OR THE PURCHASE OF ANOTHER DREDGE, CAPABLE OF OPERATING OUTSIDE THE HARBOR, TO BE DESIGNED, SPECIFIED, AND PURCHASED UNDER THE

SPONSORSHIP OF OUR SANTA CRUZ PORT DISTRICT WITH APPROVAL AND MONEY BEYOND THE DISTRICT'S $160,000 COMING FROM THE U. S. ARMY CORPS OF ENGINEERS.

OUR ORGANIZATION OFFERS ITS SUPPORT IN WHATEVER FORM WILL BE OF VALUE TO OUR PORT DISTRICT. WE FEEL WE HAVE STRONG MOTIVATION TO ASSIST AND DESERVE TO BE HEARD BECAUSE THE MEMBERS OF THE EAST CLIFF DRIVE PROPERTY OWNERS ASSOCIATION HAVE AVERAGELY SPENT $12,800 PER MEMBER FOR CONCRETE AND ROCK SEAWALLS TO FIGHT THE ACCELERATED EROSION THAT WAS TRIGGERED BY THE BUILDING OF THE SANTA CRUZ SMALL CRAFT HARBOR. THE COLLECTIVE PRIVATE COSTS FOR SHORELINE PROTECTION MAKE DREDGES LOOK INEXPENSIVE. THAT IS WHY WE CANNOT AFFORD THE LUXURY OF STILL MORE STUDIES BY THE ARMY CORPS OF ENGINEERS TO DETERMINE THE SAND-BYPASSING REQUIREMENT.

WHAT WE DO NEED IS THE FURNISHING OF SERVICES BY THE CORPS OF ENGINEERS THAT WILL KEEP OUR HARBOR OPEN AT ALL TIMES, ACCOMPANIED BY IMMEDIATE IMPLEMENTATION OF A PROGRAM THAT WILL LEAD TO PHYSICALLY PROVIDING EQUIPMENT CAPABLE OF BYPASSING 300,000 CUBIC YARDS OF SAND PER YEAR, PREFERABLY AS IT ACCUMULATES AND ON AS CLOSE TO A CONTINUOUS BASIS AS POSSIBLE.

3070 Ramona Street
Palo Alto, CA 94306
September 8, 1972

Colonel J. L. Lammie
District Engineer
Department of the Army
San Francisco District, Corps of Engineers
100 McAllister Street
San Francisco, CA 94102

Attention: SPNDE

Dear Colonel Lammie:

I had occasion to use your name last night when addressing an adjourned special meeting of the Santa Cruz Port District Commission. So you will be aware of the remarks that were made, a copy is enclosed.

It is our hope that:

1. At an early date you will address yourself to the shoaling problem at the Santa Cruz Harbor and the erosion problem along the shoreline east of it.

2. You will attempt to dissuade your Division Engineer from the passive posture he has recommended.

3. You will treat the Santa Cruz situation as an opportunity to solve a problem rather than an inherited can of worms that is to be avoided.

Knowing the funds needed to implement your proposals must come from Congress, we are bringing our plight to the attention of our elected representatives by sending them copies of this letter and statement.

Colonel J. L. Lammie
September 8, 1972
Page 2

I hope we will have an opportunity to meet sometime - perhaps along the beach - and send our organization's best wishes for success in your challenging assignment as San Francisco District Engineer.

Cordially yours,

E. W. Flavell
President

EWF:lk

cc: Senator Alan Cranston
Senator John Tunney
Congressman Charles Gubser
Santa Cruz County Board of Supervisors
Santa Cruz Port District Commission

fashion proposed. The 4R Act, by amending the 3R Act, provided for a direct authorization to fund ConRail. A massive diversion of section 511 assistance, in the absence of provision of additional such financing, might affect the ability of other railroads, particularly the marginal and bankrupt Midwest railroads, to pursue vigorously plant and equipment revitalization programs, programs which may well be essential to the survival of some railroads.

Mr. Speaker, the bill I am introducing with Mr. ROONEY, chairman of the Subcommittee on Transportation and Commerce of the Committee on Interstate and Foreign Commerce, represents an approach to the ConRail funding problem which I believe is worthy of consideration. The funds authorized by the bill would be available to deal with ConRail's problems until a comprehensive solution can be arrived at. The bill authorizes the funds to remain available until expended, so the amount and rate of funds expended will be carefully monitored by USRA under the existing statutory framework.

I would like to emphasize that this bill is not a precedent for an annual bail-out of ConRail. It represents an interim approach while a comprehensive long-term financing solution for ConRail is being formulated. Any such proposed solution will be decided on next year by the Congress with the benefit of the recommendations of the administration, which will have addressed the issues in the context of its budget process. Moreover, USRA will have had an opportunity to perform a similar in-depth study and submit its recommendations to the Congress.

Mr. Speaker, at this time I am certainly not wedded to a particular method of solving the ConRail funding problem. I think that all available options should be explored so that the Northeast region will continue to receive adequate rail services at the lowest possible cost to the taxpayer. However, I do feel that the problem should be addressed directly and forthrightly. There is general agreement that the cost of delaying certain vital capital improvement and acquisition projects that ConRail intends to pursue would severely impair its ability ever to provide adequate service and also raise the cost of such projects dramatically when they are ultimately undertaken. Of course, such delay would hardly be in the best interests of the taxpayer or of that segment of the Nation served by ConRail. The rest of the Nation would be seriously adversely affected by a poor rail connection with the Northeast quadrant, for a national rail transportation system is only as strong as its weakest link.

Mr. Speaker, the Committee on Interstate and Foreign Commerce will be taking a long hard look at ConRail's progress and prospects and will carefully study all proposals for solving the ConRail funding problem. Hopefully, with the help of all concerned about the quality of rail service throughout the Nation, we will arrive at the best solution.●

A BILL TO STUDY THE SANTA CRUZ HARBOR AND ITS IMPACT

The SPEAKER pro tempore. Under a previous order of the House, the gentleman from California (Mr. PANETTA) is recognized for 5 minutes.

● Mr. PANETTA. Mr. Speaker, last fall, I introduced legislation which would authorize funding for a study by the U.S. Army Corps of Engineers in order to develop a permanent solution to the annual blockage of the Santa Cruz small craft harbor.

In discussing this matter with local officials and residents of Santa Cruz County, it appears that the particular design problems to be dealt with in this study may be having an effect well beyond the confines of the harbor itself.

In recent years, several homes, roads, and other property have been facing a serious threat caused by cliff erosion in the area east of the harbor. Although a certain level of erosion is to be expected on ocean front cliffs of this sort, there is some indication that the harbor construction has disturbed the natural protective sand flow patterns and thus greatly increased the erosion rate.

I believe that any Federal study directed toward the development of long-range plans for the harbor facility should also take into account the possible impact of those plans on surrounding areas. For this reason, I am today reintroducing this bill with additional language to insure that this equally pressing need is given full attention by the Corps.

The bill follows:

H.R. 11485

A bill to modify the project for navigation in Santa Cruz Harbor, Santa Cruz, California, and to authorize certain studies in connection with such harbor

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the navigation project for Santa Cruz Harbor, Santa Cruz, California, authorized in section 101 of the River and Harbor Act of 1958 (Public Law 85–500) is hereby modified to provide that 100 percentum of the costs of all of the studies and research relating to the sand bypassing facility authorized as part of such project shall be paid by the United States. In addition, such project is further modified to authorize the Secretary of the Army, acting through the Chief of Engineers, to undertake such maintenance dredging outside the boundaries of the authorized project as may be necessary to prevent or mitigate shoaling, surge, and related problems in the harbor.

SEC. 2. (a) The Secretary of the Army, acting through the Chief of Engineers, shall undertake such engineering and design studies as are necessary to develop additional solutions for the shoaling, surge, and related problems in Santa Cruz Harbor, Santa Cruz, California, including such additional structural and maintenance measures as he determines necessary. In addition, the Secretary of the Army, acting through the Chief of Engineers, shall study alternative methods of more satisfactorily maintaining the channels and turning basins in such harbor. In studying such alternative methods, the Secretary of the Army, acting through the Chief of Engineers, shall determine the effect such alternative methods would have on the erosion of the cliffs located east of such harbor.

(b) The Secretary of the Army, acting through the Chief of Engineers, shall report the results of the studies authorized by this section to Congress as soon as practicable.●

COMPETITIVE PRACTICES IN THE COMMUNICATIONS INDUSTRY

The SPEAKER pro tempore. Under a previous order of the House, the gentleman from Oregon (Mr. ULLMAN) is recognized for 5 minutes.

● Mr. ULLMAN. Mr. Speaker, my colleagues, the Honorables AUCOIN and DUNCAN, join me in the following statement concerning the communications industry:

Mr. Speaker, a large number of public and private organizations, at the request of the telecommunications industry, have taken positions expressing concern that Congress should expeditiously review and determine the national telecommunications policy. They are also concerned that any policy not have an adverse impact on either the cost or quality of basic residential and basic long distance services.

The Oregon organizations who have submitted their formal position on telecommunications policy:

Corbett Kiwanis Club.
Linkville Kiwanis, Klamath Falls.
Newport Chamber of Commerce.
Toledo Chamber of Commerce.
City of Happy Valley.
Albany AARP Chapter No. 668.
Albany Chamber of Commerce.
American Business Women's Association.
Arlington Chamber of Commerce.
Arlington Senior Citizens.
Astoria—AARP.
Astoria Chamber of Commerce.
Baker County Chamber of Commerce.
Bend AARP Chapter No. 432.
Bend Chamber of Commerce.
City of Arlington.
City of Carlton.
City of Heppner.
City of Klamath Falls.
City of Medford.
City of Pendleton.
City of Warrenton.
Clackamas County Senior Citizens Council.
Commercial Club of Portland.
Condon Senior Citizens.
Corvallis Chamber of Commerce.
Dallas Senior Center.
Estacada Chamber of Commerce.
Eugene Chamber of Commerce.
Eugene Communications Workers of America Local No. 9206.
Grants Pass & Josephine County Chamber of Commerce.
Heppner-Moro County Chamber of Commerce.
Holcomb-Outlook-Park Place Neighborhood Association.
Junction City Chamber of Commerce.
Klamath Falls Board of Commissioners.
Klamath Falls Quota Club.
Lake Oswego Kiwanis.
Lane County Farm Bureau.
Lane County Labor Council.
Lents Citizens for Youth Commission.
Madras Chamber of Commerce.
Marion County Pomona Grange No. 4.
Medford Chamber of Commerce.
Medford C.W.A. Local No. 9208.
Metro East Jaycees.
Milwaukie Jaycees.
Mt. Angel Chamber of Commerce.
Mt. Angel Development Corporation.
Multi-purpose Dallas Senior Advisory Council.
National Governors Conference.

LEON E. PANETTA
18TH DISTRICT CALIFORNIA

CHAIRMAN
HOUSE BUDGET COMMITTEE

COMMITTEES:
AGRICULTURE
HOUSE ADMINISTRATION
SELECT COMMITTEE ON HUNGER
STEERING AND POLICY

MAJORITY WHIP
FOR THE BUDGET

Congress of the United States
House of Representatives
Washington, DC 20515

February 3, 1992

Mr. Ed Flavell
2940 Pleasure Point Drive
Santa Cruz, California 95062

Dear Mr. Flavell:

Thank you for taking the time to visit with me during recent constituent hours. Since establishing this format several years ago for meeting with people on an individual basis, I have come to rely on these conferences as an invaluable source of information as I review legislation that is pending before Congress. Also, I need to know when programs of the federal government, which were established to meet the needs of people, are not doing their job. It is critical that I hear about the kinds of problems people in this District are encountering.

I appreciated having the opportunity to hear about your continued interest in a proposed study by the Army Corps of Engineers, regarding beach erosion in the Yacht Harbor and Live Oak areas of the county. Therefore, as we discussed, I will set up a meeting with the Corps about this issue. My plans are to meet in the Santa Cruz area as soon as my schedule permits; I will, of course, notify you beforehand of the time and place.

With best wishes,

Sincerely,

LEON E. PANETTA
Member of Congress

LEP:kwc

EAST CLIFF DRIVE PROPERTY OWNERS ASSOCIATION
OF SANTA CRUZ COUNTY
120 - 13TH AVENUE
SANTA CRUZ, CALIFORNIA 95062

February 6, 1992

Honorable Leon E. Panetta
Member of Congress
339 Cannon House Office Building
Washington, D. C. 20515

Dear Congressman Panetta,

We thank you for having your office provide us with a copy of your House Resolution 11485, dated March 13, 1978. Your staff member Lisa Silverberg's diligence was of great value.

Although your House Resolution is fourteen years old, it us just as meaningful today as it was then. The threat from cliff erosion in the area east of the harbor to which you referred still persists. The speculation on your part that the harbor has disturbed the natural protective sand flow patterns and thus greatly increased the erosion rate is still shared by many.

It is interesting that your resolution was to provide 100% of the costs of all studies and research for the sand bypassing facility and also would authorize the Corps of Engineers to undertake maintenance dredging outside the boundaries of the harbor.

In addition you provided that the studies shall determine the effect alternative methods would have on the erosion of the cliffs located east of such harbor.

Your House Resolution 11485 addressed concerns on the part of shoreline homeowners, agencies responsible for roads and beaches, as well as the City of Capitola that were full blown as far back as 1967. It is a pity that it did not become law in 1978. If it failed for lack of local support, we can assure you that there now is support for the type of studies and action that your House Resolution 11485 proposed in 1978.

Sincerely yours,

Ed. Flavell, President — Bill Geisreiter, Secretary-Treasurer

cc: Jan Beautz, Chair, Santa Cruz County Board of Supervisors
Stephanie Harlan, Mayor of Capitola
Don Lane, Mayor of Santa Cruz
Brian Foss, Port Director, Santa Cruz Port District
Ken Christopher, Santa Cruz office of Congressman Panetta

APPENDIX III

The following is a mailing list of harbor users interviewed for this study who did not request anonymity. Businesses listed without individual contacts requested listing in this manner.

Stephen Scheiblaur, Harbormaster
Santa Cruz Port District
135 5th Ave.
Santa Cruz, CA 95062
(408) 475-6161

Joseph Townsend, Commissioner
Santa Cruz Port District
135 5th Ave.
Santa Cruz, CA 95062
(408) 462-2830

Don Starr, Former Port Commissioner, Resident West of Harbor
2032 East Cliff Dr.
Santa Cruz, CA 95062
(408)425-1120

Milt Entwistle, Past Rear Commodor
Coast Guard Auxiliary
365-Lake Ave.
Santa Cruz, CA 95062
(408)423-7119

Bob Munsey, Owner
The Crow's Nest
2218 East Cliff Drive
Santa Cruz, CA 95062
(408)476-4560

Walter Olivieri, Owner
Aldo's
616 Atlantic Ave.
Santa Cruz, CA 95062
(408)426-3736

Dave Dawson, Owner
Harbor Marine Boatyard
495 Lake Ave.
Santa Cruz, CA 95062
(408)475-3131

Bayside Marine
333 Lake Avenue
Santa Cruz, CA 95062
(408)475-2173

Kayak Connection
413 Lake Ave.
Santa Cruz, CA 95062
(408)479-1121

Bill Rawson, Manager
Fisherman's Supply/Shamrock Charters
2210 East Cliff Drive
Santa Cruz, CA 95062
(408)476-2648

Jerry Butler
O'Neill's Yachts
2222 East Cliff Drive
Santa Cruz, CA 95062
(408)476-5202

Don Dodson, President
Santa Cruz Commercial Fishermen's Association
P.O. Box 2975
Santa Cruz, CA 95063
(408)425-0536

Victor Ghio, Member, Commercial Fisherman's Association
421 Bay Street
Santa Cruz, CA 95060
(408)423-3014

Keith Bryant, Member, Commercial Fisherman's Association
2615 willowbrook Lane #84
Aptos, CA 95003
(408)475-6563

Mark Craft, Owner
Pacific Yachting
333 Lake Ave.
Santa Cruz, CA 95062
(408)476-2370

Kieth Callihan, Owner
Stagnaro Charters
Santa Cruz Municipal Wharf
Santa Cruz, CA 95060
(408)462-5065

Tim Zoliniak, Owner
Charter Boat Makaira
104 Seton Way
Santa Cruz, CA 95060
(408) 423-3775

Scott Lighthall, Charter Pilot
Chardonnay Charters
1661 Pine Flat Road
Santa Cruz, CA 95066
(408)423-1213; 429-5111

Phil Vandenburg, Director
UCSC Sailing Program
Opers Department, East Field House
1156 High Street
University of California, Santa Cruz
Santa Cruz, CA 95064
(408)425-1164

Gary Griggs, Director
UCSC Institute for Marine Sciences
Long Marine Lab
269 Applied Sciences
University of California, Santa Cruz
Santa Cruz, CA 95064
(408)459-2883; 459-2390

Gordon Smith, Researcher
UCSC Institute for Marine Sciences
University of California, Santa Cruz
Santa Cruz, CA 95064
(408)459-2883

Cliff McNamara, Former President
Santa Cruz Yacht Club
244 Fourth Avenue
Santa Cruz, CA 95062
(408) 476-3570

Tom Muller, Former President
Santa Cruz Rowing Club
210 Seabright Ave.
Santa Cruz, CA 95062
(408)429-9488

Ed Flavell, President
East Cliff Drive Property Owners Association
2940 Pleasure Point Drive
Santa Cruz, CA 95062
(408)475-7454

Connie & Joe Machutes, Members,
East Cliff Drive Property Owners Association
2870 South Palisades
Santa Cruz, CA 95062

Art Fitzsimmons, Member
East Cliff Drive Property Owners Association
2926 Pleasure Point Dr.
Santa Cruz, CA 95062

August Motnans, Member
East Cliff Drive Property Owners Association
4360 Opal Cliff Dr.
Santa Cruz, CA 95062

Carl Henn, Director of Development
Seaside Corporation
400 Beach Street
Santa Cruz, CA 95060
(408)423-5590

Bob Halterman, Harbor Representative
Seabright Neighborhood Association
121 Fourth Avenue
Santa Cruz, CA 95062
(408)423-2111

Appendix E

Geotechnical Study

APPENDIX E

SANTA CRUZ HARBOR SHOALING RECONNAISSANCE STUDY
Geotechnical Study

INTRODUCTION

Purpose. The purpose of this appendix is to present the geotechnical site conditions for four of the several alternatives being considered for reducing shoaling in the entrance channel. Other alternatives seriously being considered in the study have no significant geotechnical issues and are not included in this discussion. The four alternatives are as follows: (1) Construct a sand-catchment basin within the entrance channel; (2) Periodically remove sand from the entrance channel by permanently installed jet pumps; (3) Periodically remove sand from the beach west of the west jetty by the use of a mobile jet pump; and (4) Seal the east jetty with concrete grout to stop the through transport of sand. Longshore transported sand is carried into the mouth of the entrance channel and forms shoals in the channel. The sand-catchment basins would be sited such that hard or difficult excavation would be avoided or minimized. This appendix was written in support of the Santa Cruz Harbor Shoaling Reconnaissance Study.

Scope. The scope of this study was limited to a review of in-house geotechnical information including boring logs, design memorandum, and survey reports. Published geological literature within the in-house geological library was also reviewed.

Location and Description. Santa Cruz Harbor is a small craft harbor located near the eastern city limits of the City of Santa Cruz. The harbor opens into Monterey Bay, California, and occupies the former site of Woods Lagoon. The lagoon was a fresh water pond that extended approximately 4,500 feet inland from the ocean; the sediment in-filled portion was found to extend 1.5 miles inland. The lagoon was a drowned portion of a gully of a small stream called Arana Gulch; it was isolated from the ocean by a barrier beach and sand bar across its mouth. The outer 900 feet of the harbor entrance channel has a project depth of -20 feet mean lower low water (MLLW) and the inner 370 feet of the channel has a project depth of -15 feet MLLW. The channel is flanked on each side by rubblemound jetties. The east jetty is 850 feet in length and the west jetty is 1,125 feet in length. They were constructed during the years 1962 and 1963. The Santa Cruz Harbor is surrounded on three sides by cliffs of a large marine wave-cut terrace. This terrace also forms the cliffs along the northern edge of Monterey Bay. At the mouth of the former Woods Lagoon the cliffs on the west side are approximately 45 feet high and on the east side, approximately 20 feet in height.

GEOLOGY

General. The cliffs bounding Santa Cruz Harbor and fronting Monterey Bay in the immediate area are composed of the Purisima Formation of very late Miocene to Pliocene age, roughly 6 million to 1.8 million years before present, and the overlying marine terrace deposits. The terrace deposits consist of Quaternary age, medium to fine-grained sand and pebbles, and occasional cobbles (U.S. Army C.O.E., 1957). The terrace deposits range up to approximately 20 feet in thickness.

Within the Santa Cruz area, the Purisima Formation is described by Joseph Clark (1981, p.33) as consisting of "... very thick yellowish-gray tuffaceous and diatomaceous siltstone beds with thick yellowish-gray to locally bluish-gray andesitic sandstone interbeds." He also reports that the Purisima in the Santa Cruz quadrangle may correlate with the lower Tahana Member of the Purisima in western San Mateo County. The Purisima Formation in the Santa Cruz area dips south at 2^0 to 5^0 (Brabb, 1989) toward the Monterey Canyon, in the middle of Monterey Bay, and is believed to underlie Monterey Bay offshore of Santa Cruz. The portion of the cliffs belonging to the Purisima Formation are generally composed of sandstone and siltstone, thick bedded and weakly to moderately indurated or cemented (Griggs and Johnson, 1979).

The wave cut terrace, perhaps of the Pleistocene's Sangamon interglacial stage age (70,000 to 100,000 years ago), has not been uniformly uplifted as evidenced by the non-uniformity of the terrace elevations between Santa Cruz and Capitola (Griggs and Savoy, 1985). The changes in the terrace elevations mark the location of small faults. The sediments of the Purisima Formation are erodible. The presences of the faults, well developed joint sets, and the varying degrees of induration of the different sediment types in the Purisima greatly affect the rate of sea cliff retreat (Griggs and Johnson, 1979).

The most recent sediments, Holocene in age (less than 11,000 years old) consist of loose sand forming the beaches and a thin blanket covering the bedrock bottom of the bay. Also, fine-grained sand, silt, clay, and organic mud were deposited in Woods Lagoon (U.S. Army C.O.E., 1960). Accumulated deposits of shoaled sand along the edges of the entrance channel have locally become compacted sufficiently to make them difficult to remove with a hydraulic dredge.

Site Geology. A buried erosional feature was found from a geophysical subbottom sparker seismic-profiling survey conducted for the Corps of Engineers in 1961 over the area of the proposed jetty alignments (see Figure 1). The erosional feature consists of two merging stream channels several hundred feet in width; it has been cut into the bedrock bay floor to a depth greater than -50 feet MLLW and locally appears to exceed -60 feet MLLW (U.S. Army C.O.E. drawing, 1962). The western fork of this erosional feature is believed to represent the drainage path of Arana Gulch as it flowed towards Monterey Canyon during the lower sea level stands of Wisconsin glacial stage. Several hundred feet south of the west jetty head the drainage of Arana Gulch was joined by a second stream merging from the east, probably from the now drowned drainage feature called Schwan Lagoon. Schwan Lagoon lies approximately 1,500 feet east of the harbor entrance.

This erosional feature appears to have been partially filled and perhaps completely filled by clayey sediments as sea level rose during Holocene time. At least nine borings were performed during the 1950's for the subsurface exploration for the Santa Cruz Harbor project and most encountered very dense, cemented sands. However, three of the borings encountered clay at depth. Two of those three borings were drilled through the barrier beach at the mouth of Woods Lagoon. Of those two, one boring encountered clay at -16 feet MLLW that extended below the bottom of the boring at -27.2 feet MLLW. The second boring encountered clay at a depth of -22 feet MLLW that extended below the bottom of the boring at -28.5 feet MLLW. The third boring was drilled on the lagoon side of the barrier beach and encountered odoriferous clay between -16.3 and -23 feet MLLW and clay from -23 feet that extended below the bottom of the boring at -27.3 feet MLLW. Subsequent to the construction of the jetties, seven locations in the entrance channel between the jetties were drilled and sampled in January-February 1976. According to the boring logs six of the seven borings encountered soft to firm clayey sediments at or just below -20 feet MLLW that extended to below -35 feet MLLW. The project depth of the channel in the area of the borings is -20 feet MLLW. The boring logs are presented in Figures 2 through 8. All six locations were within or very near to the side boundaries of the erosional channel defined by the geophysical subbottom survey (see Figure 1).

Soils. Seven samples of the clayey sediments taken from the 1976 borings were sent to the South Pacific Division Laboratory for classification. Six of the seven samples were classified based on Atterberg limits and the seventh was visually classified. Four of the samples were classified as moderately plastic clays (CL), two samples as slightly to moderately plastic silts (ML), and one sample as a highly plastic clay (CH). The liquid limits of the CL and ML materials averaged 38 and the plasticity index averaged 13. Other physical properties were determined for the six moderately to slightly plastic clays and silts; their average values are as follows:

Dry Unit Weight*	86.4 pounds per cubic foot (pcf)
Moisture Content*	34.8%
% < #200 Sieve	85%
Specific Gravity	2.68

*Note that the values for dry unit weight and moisture content have not been corrected for salinity content.

A comparison of the average saturated unit weight and moisture content of the above clayey sediments with those of sediments found in San Francisco Bay was made. The comparison shows that the clayey sediments may be in the firm consistency range of the semi-consolidated younger bay mud and may approach the stiff consistency of older bay mud as presented by Ray C. Threasher (1963). Threasher's average values and those of the clayey sediments underlying the entrance channel are presented in the following tabulation.

Sediment	Average Saturated Weight	Average Moisture Content	Compressive Strength
San Francisco Bay:			
Older Bay Mud	131 pcf	<40%	1,000-4,000 psf*
Semi-consolidated, Younger Bay Mud	110 pcf	40%	1,000 psf*
Santa Cruz Harbor:			
Clayey Sediments	116 pcf	34.7%	No Data

* Pounds per square foot

The horizontal and vertical extent of the clayey sediments are not known but may extensively fill the eroded channels. The geophysical survey indicated that outside of the boundaries of the erosional feature hard, compacted material was found mantled with a very thin blanket of loose sand. This description corroborated offshore probings performed in the area during 1950. The wash probings met refusal after penetrating a thin layer of sand that became thinner, approaching less than one foot thick, in the furthest offshore locations. It is interesting to note that one probing fell between the ends of the final jetty alignment and over the filled erosional channel; it met refusal at -19.5 feet MLLW. A 1976 boring located less than 100 feet away from the probing site encountered clay in the erosional channel that extended from -20 feet to below -29 feet MLLW. Therefore, refusal of the probings may either indicate dense, cemented sediments of the Purisima Formation or firm to stiff clays of the channel filling. However, recent dredging practice by the Santa Cruz Harbor District has been to overdredge to -30 feet ± MLLW in the vicinity of the angle point at the dogleg bend of the entrance channel. There have been no known reports of dredging clays.

A comparison of hydrographic survey data from pre-construction surveys, performed in September-November 1961, with a survey performed in May 1979 indicated that a post-construction sand wedge or fillet had built up on the seaward side of the west jetty dogleg. The surface elevation of the wedge ranged from approximately -5 feet MLLW on the seaward slope of the jetty to approximately -22 feet MLLW at its toe, located approximately 360 feet seaward normal to the centerline of the dogleg. The May 1979 hydrosurvey was used as no later survey was found in the Corps of Engineers map files that extended far enough offshore.

As part of a sediment budget study conducted by Moffatt & Nichol, Engineers (1992), for the Santa Cruz Harbor Shoaling Reconnaissance Study, bathymetric profile lines were run from Station 21+00 near the head of the west jetty. The profile lines were surveyed on 28 September 1991 and 2 December 1991. They then compared the 1991 profile lines with profile lines taken from a hydrographic surveys conducted in January 1975 and May 1979 for the Corps of Engineers. Their conclusion from the comparisons was that at a depth greater than -15 feet MLLW "... the differences

between those two surveys [1991 surveys] are as large as the difference between the late 1970's and 1991 surveys, suggesting that the overall net change in this 12 to 16 year time span has been relatively small ..." They also concluded that the greatest apparent accretion has been taking place closest to Seabright Beach. This beach lies west of and abuts against the west jetty. For further information, the "Sediment Budget and Surge Study" by Moffatt & Nichol (1992) is included as Appendix B in the Santa Cruz Shoaling Reconnaissance Study.

SEISMICITY

Santa Cruz Harbor lies in a very active seismic region between two major active fault zones. The northwest trending San Andreas fault zone lies approximately 11 miles to the northeast and the more northerly trending Seal Cove-San Gregorio fault zone lies approximately 11 miles to the southwest. The active Zayante fault, which branches to the west from the San Andreas fault zone, lies approximately 8 miles to the north-northeast of the harbor while the active Monterey Bay fault zone lies immediately to the south in Monterey Bay. All of these faults and fault zones are capable of producing significant groundmotions at the harbor. For a more detailed discussion of the seismicity of the Santa Cruz area, see the February 1991 report "San Lorenzo River Levees Post Earthquake Assessment, Santa Cruz, California", U.S. Army Corps of Engineers, San Francisco District.

SLOPE-STABILITY ANALYSES

Preliminary slope-stability analyses for after-construction conditions were performed on the excavation slope of a proposed catch-basin located in the entrance channel at the angle point of the dogleg bend. The bottom of the catchment basin would be at -40 feet MLLW and the side slopes would be 3-horizontal to 1-vertical. Based upon the boring data, it was assumed that the catchment basin would be excavated in a clayey sediment which extends from -20 feet MLLW to the eroded surface of the Purisima at approximately -50 feet MLLW. The slope-stability was conducted using the UTEXAS2 slope-stability program on an IBM-clone 486 computer and under the direct supervision of the senior soils engineer.

The soil profile used in the analysis consists of rubblemound structures resting on clayey sediments that overly the Purisima Formation. The following physical parameters were selected for the after-construction condition. The rubblemound jetties were assumed to have a saturated unit weight 105 pcf, no cohesion and an angle of internal friction of 45 degrees. The clayey sediments were assumed to be homogeneous and have a saturated unit of 110 pcf. Their undrained shear strength was selected to be 350 pounds per square foot (psf) at the top of the clayey sediments and to increase with depth at a rate of 21.6 psf per foot of depth; the angle of internal friction was set equal to zero. The weak rock of the Purisima was ascribed an undrained shear strength of 2,000 psf and a saturated unit weight of 170 pcf; the angle of internal friction was set equal to zero.

The results of the analyses indicates that the 3-horizontal to 1-vertical slopes are stable when there is a 25-foot wide bench maintained between the top of the excavated slope and the toe of the jetties. The static factor of safety for a slope excavated into the clayey sediment with an undrained shear strength of 350 psf is found to be greater than 1.63. The same slope and soil strengths exhibited a factor of safety of 1.1 or greater when subjected to a seismic loading coefficient of 0.12.

The preliminary stability analyses indicates that without excavation of the catch-basin the factor of safety is 1.01 against a circular-arc failure passing through a clayey foundation for the jetty structure when subjected to a seismic loading coefficient of 0.12. The value for the undrained shear strength used in the analyses is 350 psf with a rate of strength increase of 21.6 psf per foot of depth. However, the value used for the undrained shear strength is probably conservative as no consideration was given to the strength increase as a result of foundation consolidation from the weight of the jetty structures. The structures have been inplace since 1963, at least 28 years. Also, the structures survived the October 1989 Loma Prieta Earthquakes (Ms = 7.1) with no noticeable visual damage. This earthquake caused considerable damage in the City of Santa Cruz; horizontal ground accelerations of up to 54 percent of gravity were recorded at Capitola, approximately 3 miles east of the jetties. Although no visual damage has been detected, surveys conducted in March 1988 and in November 1989 indicated that the dogleg portion of the west jetty, specifically at monuments Station 21+00 and 20+00, may have settled up to 0.25 foot. It is uncertain at this time if any permanent horizontal displacement has occurred.

ALTERNATIVES

General. The alternatives to be discussed are a sand-catchment basin in the entrance channel, removal of shoaling sand from the entrance channel by jet-pumps, removal sand from the beach west of the west jetty by a mobile jet-pump, and sealing the east jetty. These alternatives are discussed below with regards to the site geology and soils of the site.

Entrance Channel Sand-Catchment Basin. The siting of an entrance channel catch-basin is required to meet three requirements. These requirements are that the basin provide the maximum capacity to a depth of -40 feet MLLW, be located in the area of maximum shoaling, and not create an unstable slope condition which could jeopardize the overall stability and performance of the jetty structures. According to the Santa Cruz Harbor District and the San Francisco District's coastal engineering section the area of maximum shoaling in the entrance channel occurs between the west jetty Station 16+50 and the jetty heads. Based upon the recommendation of the senior soils engineer, a 25-foot wide bench between the toe of the jetty and the top of the catch-basin slope would be used to protect the stability of the jetties. The side slopes would be 3-horizontal to 1-vertical. As a result, a catch-basin with a bottom elevation at -40 feet MLLW is proposed between west jetty station 16+50 and entrance channel station 19+65. It would have a capacity of approximately 39,500 cubic yards between elevations -18 feet MLLW and -40 feet MLLW.

There are certain caveats to the basin location such as the nature of the in-filled sediments and the precise configuration of the erosional channels. If the channel fill at the above proposed site is indeed clay, then a stability analysis of the jetty and its foundation in relation to the catch basin would have to be performed as well as a stability analysis of the slopes of the catch basin. Such analyses would require collecting undisturbed samples and performing laboratory shear strength tests. Also, clayey sediments may create a problem of finding a suitable disposal site for the excavated materials. The precise configuration of the eroded channel would need to be determined in order to reduce the possibility of encountering the very difficult to dredge Purisima Formation. It is expected that a more detailed geophysical survey would be required to sufficiently delineate the eroded channel and to confirm the results of the 1961 geophysical survey. The geophysical survey should then be supplemented by vibracore borings for ground truthing prior to collecting undistributed samples for laboratory strength testing.

Entrance Channel Jet Pumps. This alternative would call for the placement of up to three jet pumps off the head of the west jetty to a depth of -40 feet MLLW. Two of the pumps would be placed in the entrance channel between the heads of the west and east jetties. The third pump is tentative; its proposed location would be east of the head of the west jetty and west of the entrance channel. The sand excavated by the jet pumps would be placed upon on the beach east of the east jetty. A constraint to the location of the pumps, as proposed, would be that the top edge of the pump craters not encroach into a zone 25 feet wide paralleling the constructed toes of the jetties. This constraint may require that the third jet pump be moved 12 to 15 feet southeast from its current planned location. This distance is based upon an assumed 2-horizontal to 1-vertical side slopes for the craters.

Caveats to the location of the jet pumps are the nature of the soils below the dredged depth of the entrance channel and the actual elevation of the eroded surface of the Purisima Formation. Jet pumps placed at -40 feet MLLW in possibly more than 10 feet of clayey sediments may not function as efficiently as planned. It may be necessary to either raise the pumps or excavate basins to place them in. However, to raise them above the clayey sediments would very likely create navigation hazards. Also, should the Purimisa Formation be found at an elevation higher than -40 feet MLLW, the pumps may have to be moved if they create a navigation hazard. The shallow elevation of the Purisima would probably mean that the piles on which the pumps are mounted may have to be socketed in a drilled hole. Thus an exploration program consisting of geophysical subbottom profiling survey, vibracore borings and perhaps undisturbed sampling would be required in order to finalize the jet pump locations.

Mobile Jet Pump. This alternative would consist of using a jet pump suspended from a crawler crane. This mobile jet pump would be used to remove sand from the beach west of the west jetty. The area to be set aside for sand removal would have a surface area of approximately 9,000 square yards, and it would be located adjacent to the approximate location

of the buried constructed toe of the west jetty. The surface elevation in the proposed pumping area currently ranges from +5 to +10 feet MLLW. Based upon refusal depth of widely spaced jet-wash probings performed in 1950, the estimated thickness of sand existing in the area is approximately 23 feet. The excavated sand would be place on the beach east of the east jetty.

If this alternative is adopted, care must be taken not to excavate below or undercut the jetty toe. Care must also be taken to prevent the public from having access to the pumping area. Craters created by jet pumping will a be a major safety hazard to the curious public.

Sealing the East Jetty. This alternative would consist of sealing the east side slope of the jetty between Stations 3+50 and 7+00 with concrete grout and placing tremied concrete along the centerline of the jetty from Stations 7+00 to 7+95. This alternative would be essentially the same as that proposed in 1985 by the Corps of Engineers for sealing this jetty. The sand would be flushed out of the B-stone layer at a depth of approximately 4 feet. The voids would then be filled with tremied concrete to form a blanket approximately 1.5 feet thick. The B-stone is believed to average 3 tons in size and have a minimum size of 2 tons. This flushing and grouting would occur from the constructed toe of the B-stone layer to the crest of the jetty. The concrete would be placed by pumping it out to the jetty, through a tremie pipe, and into the voids to be filled.

The centerline grout curtain would consist of tremied concrete placed in the voids of the B-stone crest. The B-stone crest ranges in thickness from approximately 6 feet between Stations 7+00 and 7+50 to 11 feet at Station 7+95. Ideally the tremied concrete would be placed into the underlying C-stone. However, as the size of the C-stone ranges from quarry run up to 2 tons, it is doubtful that a 4-inch tremie pipe would penetrate very far into the C-stone.

The cost estimate for this alternative is essentially based upon the preceding description. However, consideration may be given to forming a grouted cap by tremie grouting the crest of the east jetty. Then the cap could be drilled along centerline, the drill holes penetrating into the C-stone core. These holes could then be pressure washed and grouted. A sanded grout could be used for the C-stone instead of concrete.

RECOMMENDATIONS

It is recommended that, before any final siting of a sand-catchment basin or a sand jet-pump in the entrance channel is considered, the general area containing the buried erosion channel be thoroughly investigated using geophysical subbottom profiling supplemented with surveyed vibracore boring locations. The vibracores should extend at least 5 feet below the proposed bottom of the excavation but not exceed 30 feet in length. The vibracore samples should also be screened for environmental contamination prior to the final site selection.

Based upon the geophysical survey, vibracore results and engineering judgement concerning the shear strength of the sediments, a preliminary site may be selected. The preliminary site should then be investigated by collecting undisturbed samples for laboratory testing; in situ field vane shear testing may be substituted for laboratory shear strength testing should vibracore indicate the absence of laminated sediments. The final siting should be performed only after the geotechnical investigations and analysis have been fully completed.

REFERENCES

1. Brabb, Earl E., 1989, "Geologic Map of Santa Cruz County, California": U.S. Geological Survey Miscellaneous Investigation Series Map I-1905.

2. Clark, Joseph C., 1981, Stratigraphy, Paleontology, and Geology of the Central Santa Cruz Mountains, California Coast Ranges: U.S. Geological Survey Professional Paper 1168, 51p.

3. Griggs, Gary B., 1985, "Ano Nuevo to the Monterey Peninsula": in Griggs, Gary and Savoy, Lauret (editors), LIVING WITH THE CALIFORNIA COAST, Duke University Press, Durham, North Carolina, pp 178-207.

4. Griggs, Gary B. and Johnson, Rogers E., 1979, "Coastline Erosion, Santa Cruz County": in California Geology, Volume 32, Number 4, California Division of Mines and Geology, pp 67-76.

5. Moffatt & Nichol, Engineers, 1992, "Draft Report: Harbor Entrance Sediment Budget, Santa Cruz Shoaling Study": Prepared for Aqua Resources, Inc., Berkeley, California, Under Contract to U.S. Army Corps of Engineers, San Francisco District, San Francisco, California.

6. Threasher, Ray C., 1963, "Geology of the Sedimentary Deposits in San Francisco Bay, California": in Short Contributions to California Geology: Special Report 82; California Division of Mines and Geology, pp 11-24.

7. U.S. Army Corps of Engineers, 1957, "Geology, Soils, and Construction Materials: Appendix VI": in Santa Cruz Harbor, California: Survey Report, U.S. Army Engineer District, San Francisco, California, pp 1-23.

8. U.S. Army Corps of Engineers, 1960 "Geology, Soils, and Construction Materials: Appendix 1": in Santa Cruz Harbor, California: Design Memorandum No. 1, U.S. Army Engineer District, San Francisco, California, pp 1-27.

9. U.S. Army Corps of Engineers, 1962, "Santa Cruz Harbor Jetty Construction: Location of Exploration and Hydrographic & Geophysical Surveys": Drawing Number 83-9-2, Sheet 5, U.S. Army Engineer District, San Francisco, California. (Scale 1" = 100')

10. U.S. Army Corps of Engineers, 1979, "Santa Cruz Harbor: Hydrographic Survey May 16-18, 1979": Drawing Number 83-2-134, Sheet 1, U.S. Army Engineer District, San Francisco, California. (Scale 1" = 50')

11. U.S. Army Corps of Engineers, 1991, "San Lorenzo River Levees Post Earthquake Assessment": U.S. Army Engineer District, San Francisco, California.

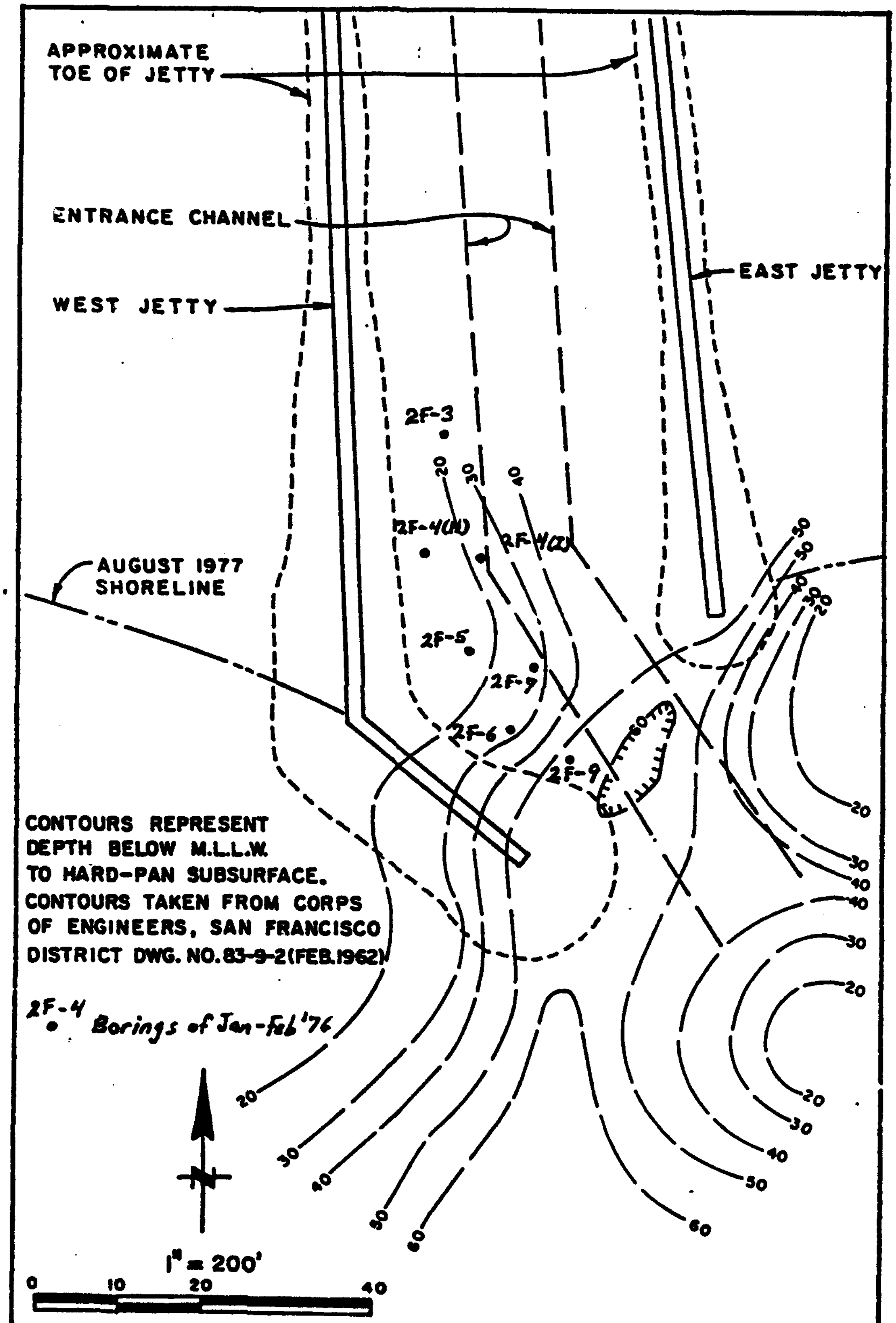


Figure E6. Depths to Hardpan (Modified)

After Moffatt & Nichol, Engineers (June 1978) "Santa Cruz Harbor Shoaling Study".

Figure 1.

BORING 2F-3 SANTA CRUZ HARBOR

20 January 1976

Elev. Ft. MLLW		Gr	Sa	Fi	LL	PL	MC	γ dry	Visual Classification and Remarks
-10.0 to -15.0	SP		98%	2%					Sand Grayish tan, fine to very fine-grained, and dense.
-20.0	SP		98%	2%					Sand Dark gray, fine to very fine-grained, dense, with some organic material.
-25.0	SP		99%	1%					Sand Grayish tan, fine to very fine-grained, and dense.
-30.0	SP		95%	5%					Sand Dark gray, fine to very fine-grained, and very dense.
-35.0	Bottom of Boring @ -35.0 Feet MLLW								

Boring drilled using a 2-inch wash bit.

Figure 2

BORING 2F-4 (I) SANTA CRUZ HARBOR

22 January 1976

Elev. Ft. MLLW		Gr	Sa	Fi	LL	PL	MC %	γ dry PCF	Visual Classification and Remarks
-18.0									Sand Dark gray to almost black, fine to very fine-grained, loose, and with much organic material such as seaweed.
-20.0	SP-SM		92%	8%			44.8	65.4	
	SP-SM		88%	12%			48.5	65.6	Less organic material
-25.0									
	CL*		29%	71%			31.1	90.4	Silt, sandy Gray, soft with fine grained sand. Occasional interbeds of thin lenses of fine to very fine-grained sand.
	CL	1%	15%	84%	38	24	34.4	86.6	
-30.0	CL		5%	95%	41	24	39.9	80.5	
	CL		18%	82%	37	22	32.7	88.7	
									No Recovery, Sample slipped out of tube.
-35.0									

Bottom of Boring @ -35.0 Feet MLLW

Samples taken using 2-inch I.D. Shelby tubes driven by a 140 lb hammer with a 30-inch drop.

* Laboratory visual classification

Figure 3

BORING 2F-4(H) SANTA CRUZ HARBOR

24 February 1976

Elev. Ft. MLLW		Gr	Sa	Fi	LL	PL	MC	γ dry	Visual Classification and Remarks
+2.0 to 0.0	SP		98%	2%					Sand Grayish tan, fine to very fine-grained, and medium dense
-5.0	SP		98%	2%					
-10.0	SP		98%	2%					
-15.0	SP		99%	1%					
-20.0	CL*		20%	80%					Clay, silty Dark gray, soft, wet, and with occasional fragments of broken shell.
-25.0	CL*		40%	60%					
-30.0	CL*		39%	61%					
-35.0									

Bottom of Boring @ -35.0 Feet MLLW

Boring drilled using a continuous flight auger, 4-inch diameter.

* Laboratory visual classification

Figure 4.

BORING 2F-5 — SANTA CRUZ HARBOR

24 February 1976

Elev. Ft. MLLW		Gr	Sa	Fi	LL	PL	MC	γ dry	Visual Classification and Remarks
+2.0									
0.0	SP		99%	1%					**Sand** Grayish tan, fine to very fine-grained, and medium dense.
-5.0	SP		98%	2%					
-10.0	SP		98%	2%					
-15.0	SP		98%	2%					
-20.0	CL*		16%	84%					**Clay, silty** Gray, soft, wet, and with occasional shell fragments or small gravel.
-25.0	CL*		16%	84%					
-30.0	CL*	1%	5%	94%					
-35.0									

Bottom of Boring @ -35.0 Feet MLLW

Boring drilled using a continuous flight auger, 4-inch diameter.

* Laboratory visual classification

Figure 5.

BORING 2F-6

SANTA CRUZ HARBOR

24 February 1976

Elev. Ft. MLLW		Gr	Sa	Fi	LL	PL	MC	γ dry	Visual Classification and Remarks
+2.0									
0.0	SP		98%	2%					Sand Grayish tan, fine to very fine-grained, and medium dense.
-5.0	SP		98%	2%					
-10.0	SP		98%	2%					
-15.0	SP		98%	2%					
-20.0	SP		97%	3%					
-25.0	CL*		19%	81%					Clay, silty Dark gray, soft and wet.
-30.0	CL*		16%	84%					
	CL*		15%	85%					
-35.0	Bottom of Boring @ -35.0 Feet MLLW								

Boring drilled using a continuous flight auger, 4-inch diameter.

* Laboratory visual classification

Figure 6.

BORING 2F-7 SANTA CRUZ HARBOR

24 February 1976

Elev. Ft. MLLW +2.0		Gr	Sa	Fi	LL	PL	MC	γ dry	Visual Classification and Remarks
0.0	SP-SM		95%	5%					Sand Grayish tan, fine to very fine-grained, and medium dense.
-5.0	SP		98%	2%					
-10.0	SP		99%	1%					
-15.0	SP		98%	2%					
-20.0									
-25.0	CL*		6%	94%					Clay, silty Dark gray, soft, and wet
-30.0	CL*		7%	93%					
-35.0	CL*		5%	95%					

Bottom of Boring @ -35.0 feet MLLW

Boring drilled with a continuous flight auger, 4-inch diameter.

* Laboratory visual classification

Figure 7.

BORING 2F-9 SANTA CRUZ HARBOR

26 February 1976

Elev. Ft. MLLW		Gr	Sa	Fi	LL	PL	MC %	γ dry PCF	Visual Classification and Remarks
+1.0									
0.0	SP-SM		92%	8%					Sand Grayish tan, fine to very fine-grained, loose, and wet. Distrubed sample
-5.0									
	SP	1%	99%				22.2	98.3	
-10.0	SP		98%	2%			23.1	98.1	medium dense
	SP		96%	4%			26.6	94.8	Sand Dark gray, fine to very fine-grained, medium dense, and wet.
-15.0									
	SP	1%	97%	2%			22.3	99.0	Contain's undecayed organic material
	SP*								
-20.0	CH		2%	98%	84	29	66.4	59.9	Clay, silty Grayish tan to gray, firm, and wet.
	ML		2%	98%	39	27	36.7	84.5	
-25.0									
	ML		16%	84%	35	27	33.7	87.9	
-29.5									

Bottom of Boring @ -29.5 feet MLLW

Boring began with a 4-inch diameter continous flight auger. Then collected samples using 2 3/4-inch x 30-inch steel Shelby tubes driven by 140-lb. hammer with a 30-inch drop.

* Laboratory visual classification

Figure 8.

Appendix F

Primary Alternative Cost Estimates

ALTERNATIVE 1: NO PROJECT

COST ESTIMATE

ALTERNATIVE 2: EAST JETTY SEALING

SANTA CRUZ HARBOR
EAST JETTY SEALING
COST ESTIMATE *

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
1.	MOBILIZATION AND PREPARATORY WORK	1	JOB	L.S.	8,800
2.	EXCAVATION	4500	C.Y.	18.40	82,800
3.	FLUSHING OF JETTY	100	HRS.	66.00	6,600
4.	CONCRETE, CLASS I	255	C.Y.	346.00	88,200
5.	CEMENT, CLASS I CONCRETE	20	CWT.	10.00	200
6.	ANTI-WASHOUT ADMIXTURE	1550	LBS SOLIDS	14.50	22,500
7.	WATER-REDUCTING ADMIXTURE	255	C.Y.	5.45	1400
8.	CONCRETE, CLASS II	110	C.Y.	414.00	87,000
				TOTAL	$297,500
			TOTAL (ROUNDED)		$300,000

*Cost Estimate includes overhead, bond, profit, and contingency.

COST ESTIMATE

ALTERNATIVE 3: DREDGING PIPELINE EXTENSION

SANTA CRUZ HARBOR
DREDGING PIPELING EXTENSION
COST ESTIMATE

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
1.	FUSING TECHNICIAN	DAYS	2	375.00	750
2.	EXPENSES - TRAVEL	MI	100	0.75	75
3.	FRINGES, ETC.		INCL.		
4.	22 LENGTHS (40' X 16" I.D.) HIGH DENSITY POLY PIPE - 100 PST	LF	880	14.75	12,980
	FUSING MACHINE	DAYS	2	225.00	450
	TAX - 8.25%				1,108
5.	F.O.B JOB SITE-FREIGHT				500
				SUBTOTAL	$15,863
6.	OVERHEAD, BOND, & PROFIT(24.43%)				3,875
				TOTAL	$19,738
				TOTAL (ROUNDED)	$20,000*

*Contingency excluded based on a contractor estimate of $17,000.

COST ESTIMATE

ALTERNATIVE 4: CHANNEL SAND TRAP

SANTA CRUZ HARBOR
CHANNEL SAND TRAP
COST ESTIMATE

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
1.	MOB & DEMOB - ON SITE				
2.	MAINT DREDGE (HYDRAULIC) 3X/YR - DREDGE ON SITE	130,000	C.Y.	2.50	325,000
				TOTAL	325,000
			TOTAL (ROUNDED)		$330,000*

*Excludes Contingency; based on existing dredging operation by Santa Cruz Port District.

COST ESTIMATE

ALTERNATIVE 5: OFFSHORE SAND TRAP

Offshore Sand Trap
for
San Cruz for Harbor

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
1.	Mob & Demob*	1	Job	LS.	$16,000
	Survey	1	Job	LS.	8,000
2.	Pump Barge Dredge Dredge & Tug Boat	208,000	CY	$1.60	332,800
				SUBTOTAL	356,800
Bond, Profit 9%					32,100
				SUBTOTAL	388,900
Contingency 25%					97,225
				TOTAL	486,125
				TOTAL (ROUNDED)	$490,000

* Based on dredge already passing through greater Monterey Bay area.

COST ESTIMATE

ALTERNATIVE 6: FIXED JET PUMPS

SANTA CRUZ FIXED DREDGING SYSTEM

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
1.	MOB/DEMOB		LS		12,000
2.	PUMP BLDG (1144SF) & MISCL. (INCL HOIST, STEEL, CHEM. TOIL., FOUND, HVAC, ETC.)	1144	SF	60.45	69,153
	MOTIVE PUMP, POWER, COUPLING, VALVES	1	EA	169,000.00	169,000
	BOOSTER PUMP, POWER, V-BELT RED., COUPLING	1	EA	265,000.00	265,000
	JET PUMPS W/RUBBER HOSE, VALVES, ETC.	2	EA	177,500.00	355,000
	JET PUMP UNDERWATER "H" MOUNTS	2	EA	25,000.00	50,000
3.	16" D H.S.H.D.P. PLASTIC PIPE-ABV. GRND.	1554	LF	30.00	46,620
4.	16"D H.S.H.D.P. PLASTIC PIPE, UND, CHANNEL	670	LF	50.00	33,500
5.	16" D STL, PIPE IN PUMP HOUSE. W/FITTINGS, ETC.	200	LF	150.00	30,000
6.	TRANSF. BLDG, ELECT, DIST., BITUM, PAVING, DUCT W/CONC, FOUND., ETC.	200	SF	692.92	138,584
7.	PUMP BLDG. PIPING	200	LF	405.77	81,153
	SUBTOTAL - BALANCE				1,087,704
	SALES TAX-8.5% (ON MATERIALS ONLY)				43,801
	BOND, OH + PROFIT				22,528
				SUBTOTAL	1,235,186
	CONTINGENCY 25%				308,796
				TOTAL	1,543,982
				TOTAL (ROUNDED)	$1,600,000

SANTA CRUZ FIXED DREDGING SYSTEM
ADDITIVE BID ITEM NO. 1

SUBITEM	PLANT	LABOR	MATERIALS	SUBTOTAL
ADD (1) JET PUMP W/ ROUBBER HOSE, VALVES, ETC.		88,750	88,750	177,500
ADD "H" MOUNT		12,000	13,000	25,000
16" D H.S.H.D.P. PLASTIC PIPE, UND. WTR. 142. LF	2,130	2,130	2,840	7,100
SUBTOTAL	2,130	102,880	104,590	209,600
SALES TAX 8.5% (PIPE & "H" MOUNT)			1,346	1,346
			TOTAL	210,946
			TOTAL (ROUNDED)	$211,000

SANTA CRUZ FIXED DREDGING SYSTEM
ADDITIVE BID ITEM NO. 2

SUBITEM	PLANT	LABORS	MATERIALS	SUPPLIES	SUBTOTAL
150 KW - 227 HP DIESEL GENERATOR	1 ea			35,000	35,000
DIESEL FUEL	1,600 gal 200 hrs		2,400		2,400
OPERATOR-INCL IN BASE BID					
HOOK UP		1,000	4,000		5,000
SUBTOTAL		1,000	6,400	35,000	42,400
SALES TAX 8.5% (MATERIALS & SUPPLIES)			544	2,975	3,519
				SUBTOTAL	$45,919
CONTINGENCY 25%					11,479
				TOTAL	$57,398
				TOTAL (ROUNDED)	$57,500

SANTA CRUZ FIXED DREDGING SYSTEM
YEARLY OPERATING EXPENSE

SUBITEM		LABOR	MATERIALS	SUPPLIES	SUBTOTAL
INCL. FRINGES					
PUMP OPERATOR	1460 hrs @ 25/hr	36,500			36,500
DECK HANDS (2)	600 hrs @ 30/hr	18,000			18,000
DREDGE MASTER	300 hrs @ 45/hr	13,500			13,500
POWER (PG & E)	1,200,000 kw/yr @ .074/kw			88,800	88,800
WEAR COST PUMPS/PARTS	1,000 hrs @ 30/hr		30,000		30,000
SALES TAX 8.5%			2,550		2,550
				SUBTOTAL	189,350
CONTINGENCY 10%					18,935
				TOTAL	208,285
				TOTAL (ROUNDED)	$210,000

COST ESTIMATES

ALTERNATIVE 7: MOBILE JET PUMPS

SANTA CRUZ HARBOR
MOBILE JET-PUMP SYSTEM
COST ESTIMATE*

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
1.	Eductor, Assemblies & Extensions (2)	1	Job		60,000
2.	Pump & Engine Sets (1) Supply Water (1) Slurry Booster	1	Job		180,000
3.	Pipe (Above Ground-10" Plastic)	2,224	LF	45	100,080
4.	Pipe (In Pump House-10" Steel)	200	LF	65	13,000
5.	Density & Flow Meters	1	Job		30,000
6.	Building (not including Pump, Piping, Instrumentation)	1	Job		150,000
7.	Overhead, Bond, Profit, etc.	1	Job		428,920
	Sub Total (Delaware Bid)				962,000
	Area Cost Factor (Delaware to California)	8.04%			77,345
	Subtotal (California)				1,039,345
	Cost Index (2/89 to 3/92)	8.04%			88,136
	Subtotal (3/92, California)				1,127,481
8.	Steel Mats (for 70-ton Crane)	10	Each	4,000	40,000
				Subtotal	1,167,481
	Contingency	25%			291,481
				Total	1,495,315
				Total (Rounded)	1,500,000

* Costs based on actual bid dated 7 FEB, 1989.
(Submitted for Indian River, Delaware.)

SANTA CRUZ HARBOR
ANNUAL OPERATION & MAINTENANCE COST
MOBILE JET-PUMP SYSTEM

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
1.	Existing 70-Ton Crane Maint. & Lube (Actual Costs)				2,218
2.	Crane Operator	1,000	Hrs	39.69	39,690
	Laborers (2)	2,000	Hrs	23.09	46,180
3.	Depreciation (Accelerated)	1,000	Hrs	23.35	23,350
4.	Cost of Facilities Capital	1,000	Hrs	12.67	12,670
5.	Fuel	1,000	Hrs	5.89	5,890
				Subtotal	129,998
	Contingency 10%				13,000
				Total	142,998
			Total (Rounded)		150,000

Appendix G

Real Estate Cost Estimates

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
211 MAIN STREET
SAN FRANCISCO, CALIFORNIA 94105 - 1905

CESPK-RE-CP (405-10f) 20 April 1992

MEMORANDUM FOR Commander, San Francisco District, ATTN: CESPN-PE-W (Tom Kendall)

SUBJECT: Real Estate Cost Estimate for Santa Cruz Harbor Shoaling Study, Monterey Bay - Reconnaissance Level

1. Enclosed is the real estate cost estimate for the subject reconnaissance study completed by our staff appraiser. The cost estimate addresses the three alternatives requiring acquisition of real estate: Alternative 3, extension of the dredge pipeline for subsequent deposition of sand further eastward toward Black Point; alternative 5, fixed jet pump sand by-passing system; and alternative 6, mobile jet pump system.

2. For each alternative, a breakdown of costs are provided as follows:

a. Alternative 3, Extension of Dredge Pipeline.

Lands and Damages

Permanent Easement 6000 sq ft	$211,000
Contingencies	52,750
Severance Damages	21,100
Subtotal	$284,850

Administrative Cost

Non-Federal	$ 20,000
Federal	10,000
Subtotal	30,000
Rounded Total	$315,000

b. Alternative 5, Fixed Jet Pump

Lands and Damages

Permanent Easement	1.58 acres	$211,000
Lease	10,000 sq ft	91,000
Contingencies		75,500
Severance Damages		30,200
Subtotal		$407,700

Administrative Costs

Non-Federal	$ 20,000
Federal	10,000
Subtotal	30,000
Rounded Total	$440,000

CESPK-RE-CP (405-10f) 20 April 1992
SUBJECT: Real Estate Cost Estimate for Santa Cruz Harbor Shoaling Study, Monterey Bay - Reconnaissance Level

c. Alternative 6, Mobile Jet Pump

Lands and Damages		
Permanent Easement	3.7 acres	$587,000
Contingencies		146,750
Severance Damages		58,700
		792,450
Rounded Subtotal		$800,000
Administrative Costs		
Non-Federal		$ 20,000
Federal		10,000
Subtotal		30,000
Total		$830,000

3. We have estimated the administrative costs for all three alternatives based on one ownership. The non-federal costs is estimated at $20,000 per ownership and the federal cost at $10,000 per ownership. These costs are based on guesstimates from other projects in the crediting phase and includes all efforts from start of P.E.D. through crediting.

4. Point of contact is Nancy Mullen, X6968.

FOR THE COMMANDER:

Encl

MARVIN D. FISHER
Chief, Real Estate Division

RECONNAISSANCE LEVEL COST ESTIMATE

OF

SANTA CRUZ HARBOR
SHOALING STUDY

MONTEREY BAY
SANTA CRUZ COUNTY, CALIFORNIA

for

SAN FRANCISCO DISTRICT
U. S. ARMY CORPS OF ENGINEERS
ENGINEERING DIVISION
WATER RESOURCES

by

REAL ESTATE DIVISION
APPRAISAL BRANCH
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

MARCH 1992

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
STATEMENT OF DISTRICT REVIEWING APPRAISER

1. PROJECT: Santa Cruz Harbor Shoaling Study

2. PROPERTY APPRAISED: Reconnaissance Level
Santa Cruz Harbor Shoaling
Santa Cruz County, California

3. APPRAISER: Brian Kirchner

4. PROPERTY INTEREST: Non Standard Access and Storage Permanent Easeme
Temporary Work Area Easement

5. DATE OF VALUE: 26 March 1991
6. DATE OF REPORT: 31 March 1992

8. SCOPE OF REVIEW: This is a desk review but, the reviewer is familiar with subject's general area.

9. REVIEW COMMENTS:

The overall appearance and arrangement of the written report is done in a professional manner. All areas necessary to support Mr. Kirchner's valuation have been adequately covered.

The Market Data Approach was used for the basis of valuation. The appraiser supported his conclusions by investigating and analyzing market data using numerous sale transactions. The appraiser's explanation of his conclusions are rational and clear and the treatment of the data is considered reasonable.

The overall conclusions are reasonable; I concur in and approve the total real estate value as follows:

Extension of Dredge Pipeline	$ 285,000
Fixed Jet Pump	410.000
Mobile Jet Pump	800,000

10. REVIEWER CERTIFICATION

I certify that I have no past, present or intended future interest in the subject property or area.

DATE: 9 April 1992

Ted Martin

TED MARTIN
District Reviewing Appraiser

DEPARTMENT OF THE ARMY

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

RECONNAISSANCE COST ESTIMATE

SANTA CRUZ HARBOR SHOALING STUDY

1. AUTHORITY

This report is prepared in response to Military Interdepartmental Purchase Request No. E86 92 3011 United States Army Corps of Engineers San Francisco District, Engineering Division, Water Resources Branch dated 17 March 1992.

2. PURPOSE

Possible alternatives to reduce shoaling, minimize dredging operations and optimize placement of sand at the entrance of Santa Cruz Harbor have been formulated to keep the channel open for safe navigation. In order to implement an alternative, temporary work, staging, and storage areas will be necessary at the harbor. This cost estimate outlines the cost of utilizing these areas.

3. FUNCTION

The value estimates developed in this reconnaissance level cost estimate report will be used to indicate the cost of acquiring seasonal storage areas and construction staging areas for the various alternatives.

4. DATE OF VALUE

The date of value is 26-March-1992.

5. ASSUMPTIONS AND LIMITING CONDITIONS

This report and the value estimates it contains are expressly subject to the following:

A. No responsibility is assumed for matters which are legal in nature.

B. The information and the data secured by the appraiser, verbal and written, is considered to be from reliable sources; however, no guarantee is made as to its absolute accuracy.

C. If any of the valuation estimates developed in this report are used in another report or document, this report should be cited as the source by footnote.

D. Maps and other illustrations used herein are for illustration and are provided only to assist the reader in visualizing the property. They are believed to be reliable and indicative of the property appraised but are not represented as legal surveys, nor for legal reference.

E. Any adjustment, revision or change in the application of data or values as they appear in this report will invalidate same, unless approved by the Real Estate Division, Appraisal Branch.

F. This appraisal is based on data available at the time of the valuation, and no conditions exist that were not discoverable through a normal, diligent investigation. If additional information is received at a later date, that information could affect the valuation estimate.

G. Possession of this report or a copy of this report does not carry with it the right to publication or reproduction without the written consent of the Real Estate Division, Appraisal Branch.

H. Where physical construction of the project requires it, provisions will have to be made for the relocation of utilities, roads, and railroad lines.

I. The values estimated in this report are based on the assumption that title is clear and marketable, free of liens such as mortgages, deeds of trust, and judgments. Title will be taken subject to existing public easements and assessment bonds. The property appraised value is based on the property being under prudent and responsible ownership and management.

6. SPECIAL FEATURES

This cost estimate did not include any supplemental value for subsurface mineral deposits and/or rights. The physical inspection of the sites did not discover any mineral rights such as oil or gas or timber that would affect the cost estimate in the project area. If such conditions were later discovered or disclosed the cost estimate could be adjusted contingent upon verification and/or correction by a qualified expert.

7. SITE INSPECTION DATES

The proposed temporary work, staging and storage areas for the various alternatives at Santa Cruz Harbor were inspected with the harbor master Steve Scheilblauer on March 26, 1992.

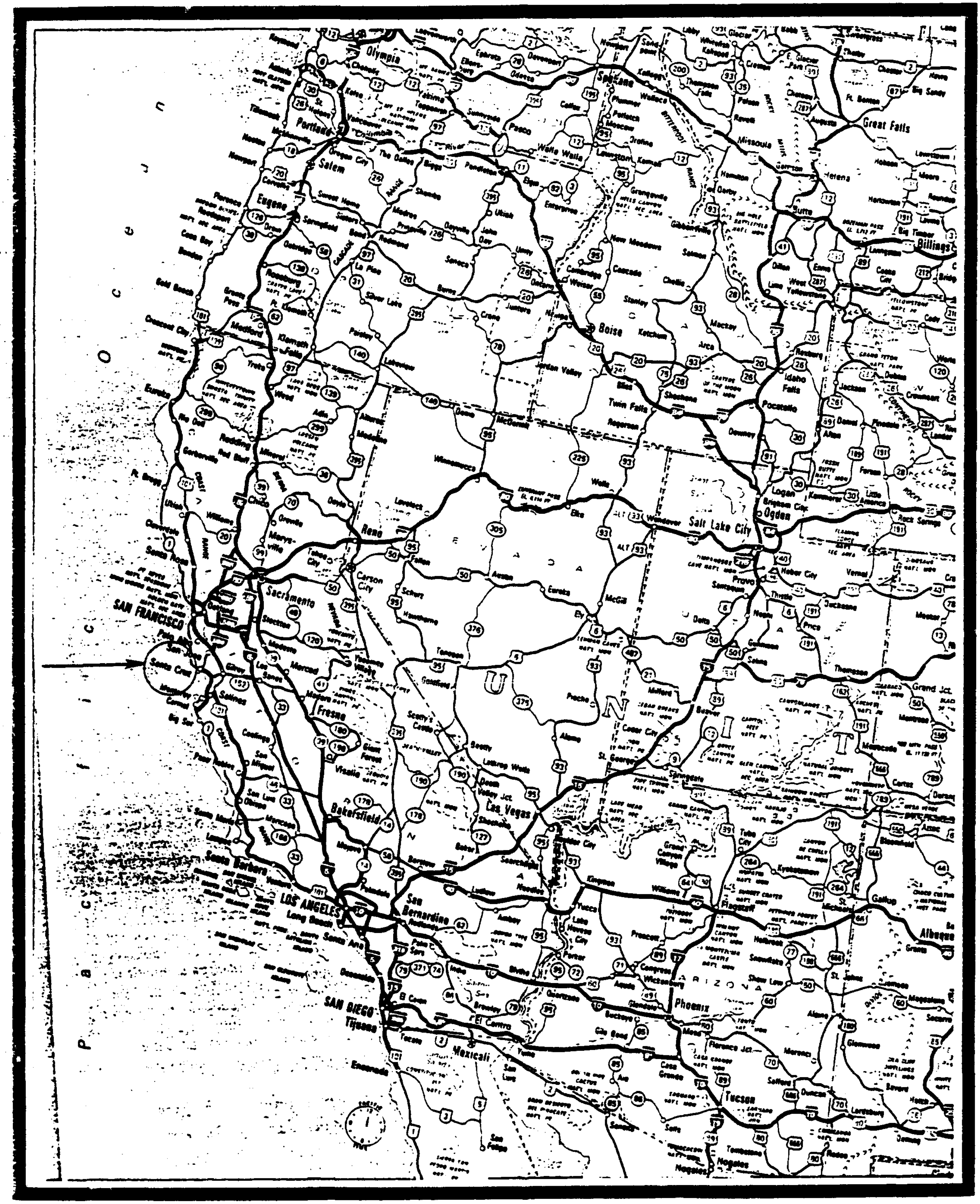
8. GENERAL PROJECT AND AREA DESCRIPTION

Santa Cruz Harbor is situated in Santa Cruz County California and is located approximately 65 miles south of San Francisco. The harbor is situated at the northern end of Monterey Bay, between Point Santa Cruz and Soquel Point. The harbor is a small craft harbor located near the eastern city limits of Santa Cruz.

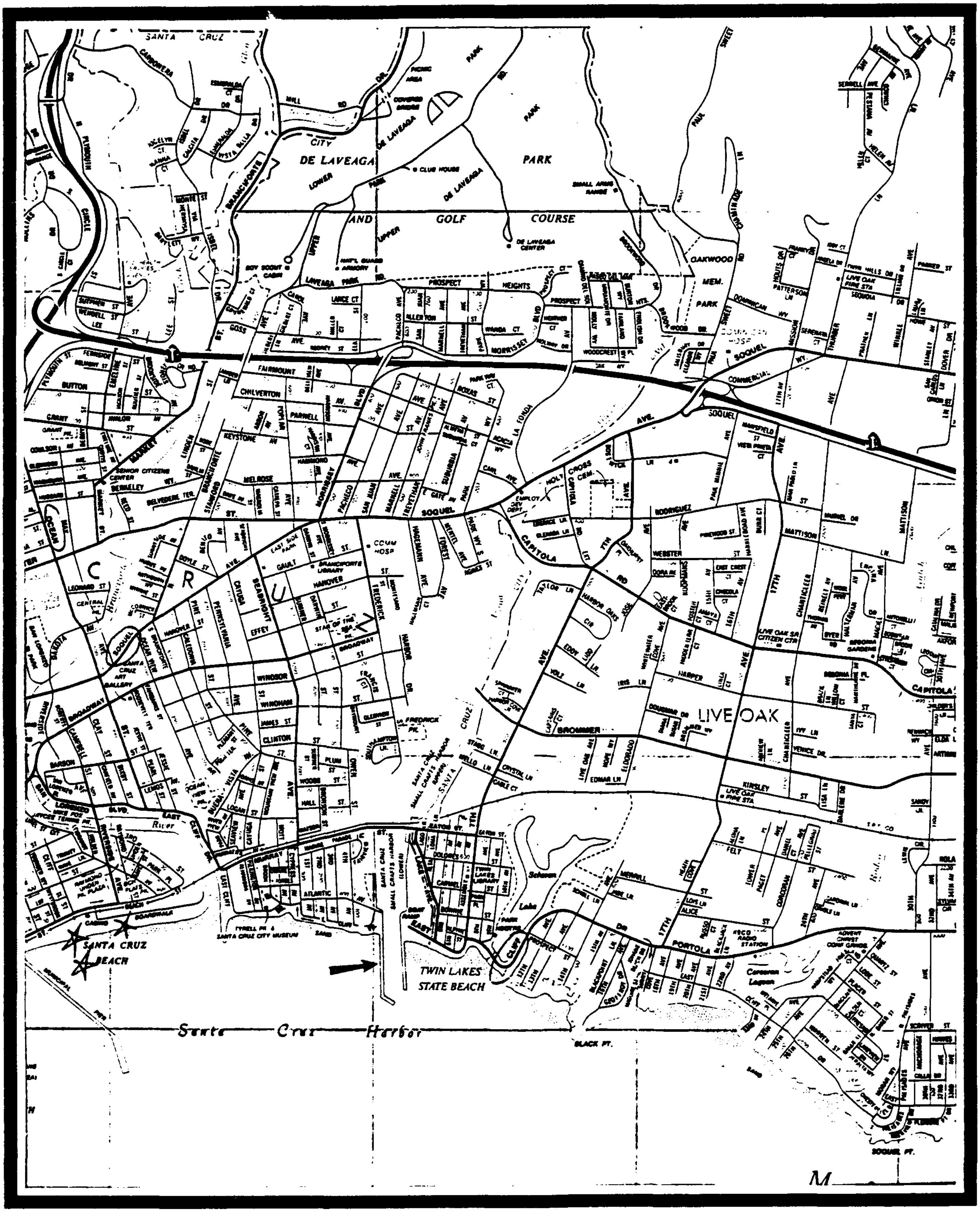
The climate of the Monterey Bay area is considered to be coastal Mediterranean. The moderate maritime climate has a general pattern of wet winters and relatively dry summers. Relatively stable water temperatures combined with the upwelling and nutrient mixing from the Monterey Canyon make the ocean highly productive. The area supports a wide variety of marine and terrestrial life.

Santa Cruz Harbor opens into Monterey Bay and is the former site of Woods Lagoon. The channel into the harbor is flanked on each side by rubble mound jetties. The east jetty is 850 feet long and the west jetty is 1,125 feet in length. The Santa Cruz Harbor entrance was designed by the U.S. Army Corps of Engineers beginning in 1962 and was completed in 1963.

The beach west of the jetties created a large sand trap of annual downcoast sand transport. As the sand trap filled, maintenance requirements began to increase and harbor closures became frequent due to sand entering and clogging the harbor entrance. Maintaining the harbor entrance became a challenge to the Federal Government and the local interests at the Santa Cruz Port District. Clearing of the harbor entrance has been carried out by dredging operations.

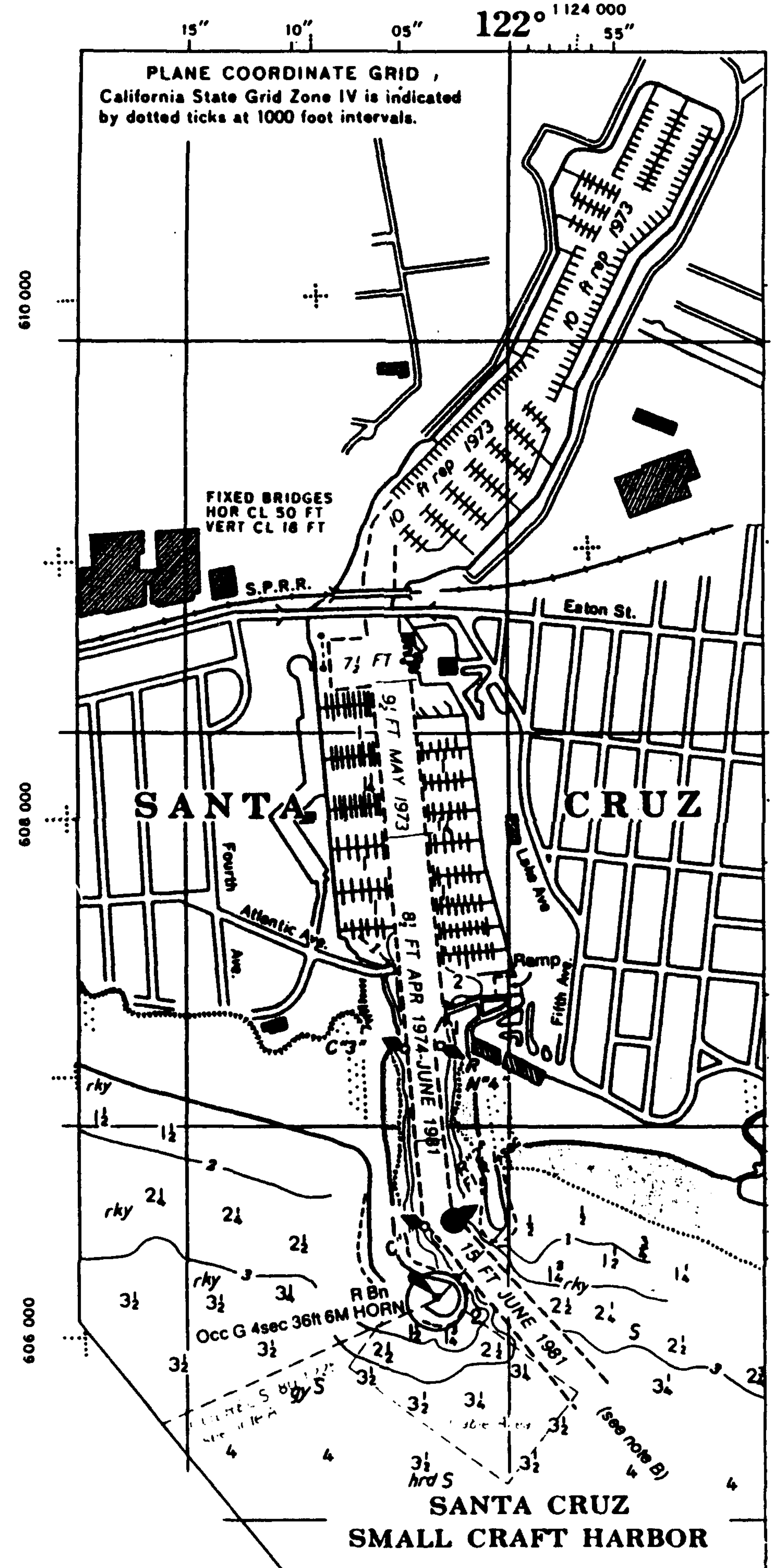


Regional Location Map



Real Estate Graphics, Inc. ©COPYRIGHT 1976

Location Map



SANTA CRUZ
SMALL CRAFT HARBOR

Scale 1:10,000

8. <u>GENERAL PROJECT AND AREA DESCRIPTION CONTINUED</u>

Several dredging setups were used before an adequate dredger was acquired. In spite of the intensive dredger maintenance program, the combined effects of storm waves and high sand transport can make the harbor unnavigable for a portion of the winter. These processes contribute to the accretion of sand into a bar at the tip of the west jetty. This bar causes waves to break across the harbor entrance and surge problems occasionally plague the back of the harbor.

Long term alternatives to solving the shoaling problem and reduce the intensive dredging operations ~~and~~ have been under intensive review and study. The objectives are to eliminate harbor use delays for commercial fishermen and recreational boaters, reduce the annual dredging cost which maintains the channel, and make the harbor entrance safe for navigation.

The six alternatives which been studied are:

1. No Action
2. East Jetty Sealing
3. Extended Discharge Pipeline
4. Sand trap
5. Fixed Jet Pump System
6. Mobile Jet Pump System

The alternatives that have real estate requirements are

3. Extension of the dredge pipeline for subsequent deposition of sand further eastward toward Black Point

5. Fixed Jet-Pump sand bypassing system

6. Mobile Jet Pump System working along the west jetty bypassing sand to the east beach.

9. VALUATION

HIGHEST AND BEST USE: The use, from reasonably probable and legal use of vacant land or an improved property, which is physically possible, appropriately supported, financially feasible, and results in the highest value.

The storage, work and staging areas needed to implement the alternatives consist of sites located at the Santa Cruz Harbor property. The highest and best use of these sites are uses commonly associated with a commercial boat harbor facility. The highest and best use of these sites varies from parking and storage areas with potential to commercial development. Portions of the harbor would not be sold separately as the City of Santa Cruz Harbor operates as a single entity. The portions we would utilize on a temporary basis have been valued on a lease basis. The permanent easement areas are considered tantamount to fee since the easement would be in perpetuity.

ESTATES APPRAISED

The type of easement needed for the plastic pipe storage for the dredge pipeline extension alternative will be a permanent access easement with rights for egress and ingress for the sites.

The type of easement needed for the fixed jet pump alternative will be a temporary work area easement for the staging areas, and the equipment walking area will be a non-standard permanent access easement with rights for egress and ingress to the walking area along the west jetty.

The type of easement needed for the mobile jet pump alternative is considered to be a non-standard permanent access easement with rights for egress and ingress to the walking area along the west jetty. The estates needed for the crane storage areas will be permanent access easement with rights for egress and ingress for the sites.

COMPARABLE SALES DATA

The project area property site values are based on a search and analysis of vacant commercial property sales. Additional information and sales data was also arrived from various knowledgeable sources in the regional real estate market.

Commercial comparable sales activity ranged from a low of $25 per square foot to a high of $95 per square foot. The typical range per square foot was from $50 to $75.

The lease data used for the temporary staging area was arrived from information from several ground leases at the harbor and the data was furnished by Santa Cruz Harbor.

10. CONTINGENCY

The contingency factor used in this report was based on (1) the level of the report, (2) time constraints, (3) minor project design changes, and (4) market data availability. The severance damage allowance has been listed separately in the cost estimate section.

11. CONTAMINATION AND TOXIC CONCERNS

Any hazardous, toxic and radiological wastes (HTRW) sites located in the study area could require special design or construction considerations for the proposed staging, temporary work and storage areas. Federal and State lists are available for review and may be helpful in determination of the extent of known HTRW identified sites located in the study area. However, the lists are of limited use for sites which have not been identified. The Santa Cruz Harbor operates in an environmentally sensitive area, and it appears the city adheres to sound and stringent policies.

The project area has been visually inspected and there appeared to be no apparent hazardous or toxic substances. However, the appraiser is not qualified to detect hazardous or toxic substances, nor qualified to determine the effect, if any, of unknown or known substances. The cost estimate is based on the project area being free of hazardous waste contamination, and should an assessment indicate an adverse condition does exist the conclusions of this report may need revision.

12. COST ESTIMATE

The following addresses the reconnaissance level cost estimates separated by the alternatives with real estate needs.

EXTENSION OF DREDGE PIPELINE

Lengthening the dredge pipe and the subsequent deposition of sand further eastward toward Black Point may prevent sand redeposition in the harbor by waves approaching from the south and southeast.

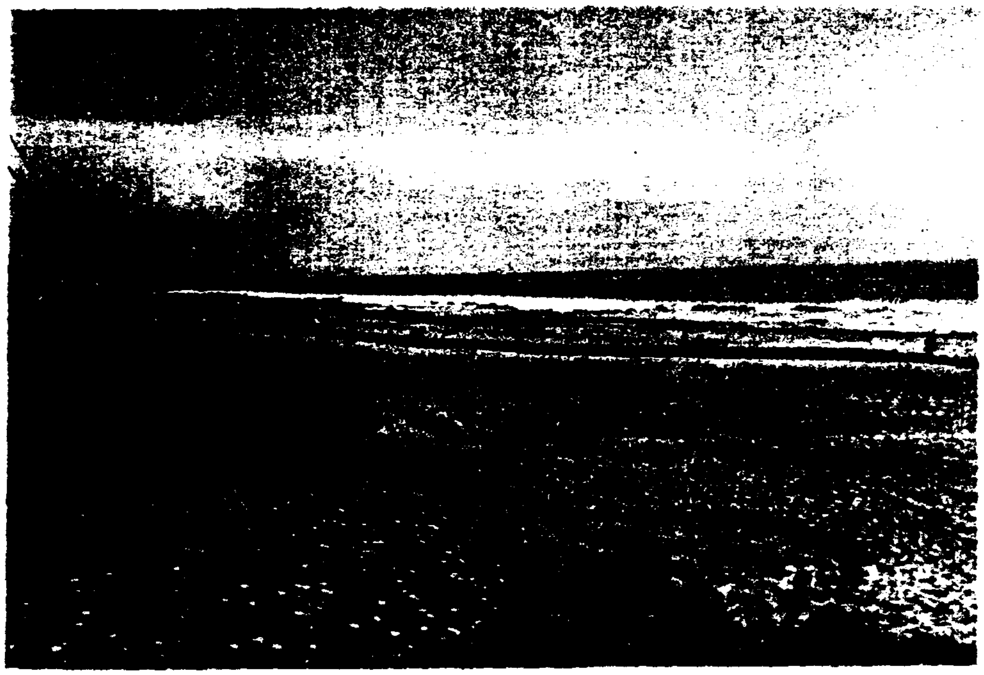
Purpose	**Time Needed**	**Area Square Feet**	**Price per sq. ft.**	**Estate to be Acquired**	**Estimated Cost**
Plastic Pipe Storage	Summer	6000	$35.00	Permanent Easement	$210,000
Plastic Pipe Storage	Winter	6000	NOMINAL	Permanent Easement	$1,000

Summer plastic pipe storage would be located in the upper harbor. The plastic pipe would be stored along the visitor parking area and hillside edge. Presently this narrow area is being utilized for rainfall runoff drainage, and could potentially be developed to stackable mini-storage and or extension of existing parking lot.

The winter storage of plastic pipe would be situated on Twin Lakes State Beach. Winter time use of the public beach is limited. This area is considered to be of nominal value as the beach is considered to be public domain. A nominal value of $1,000 has been assigned to this area. Building of structures or significant alteration of the beach is not permitted due to local, state, and federal government and coastal commission regulations and restrictions. The beach is reserved to public use for recreational activities such as walking, swimming at the ocean, surfing, shellfishing, etc...

The location of these storage areas are illustrated on the following as exhibit A.

PHOTOGRAPHS for Extension of Dredge Pipeline



East Beach looking east which shows the existing dredge discharge pipeline.

East Beach looking southeast showing the approximate location of the winter plastic pipe storage area.

PHOTOGRAPHS for Extension of Dredge Pipeline

Summer plastic pipe storage located in the upper harbor on the eastern side. Pipe storage would be placed between the parking curb and the hillside.

12. COST ESTIMATE CONTINUED

FIXED JET PUMP

Deposition of sand in the harbor entrance would be alleviated by placing a sand passage device in the channel. The sand would be pumped on the beach eastward in a fashion similar to the existing dredge operation. This all-weather option would ease the burden on the dredge and permit faster clearing of the harbor after storms. This option entails the placement of a second pipe parallel to the dredge pipe currently in use. A permanent building to house the pump on the west jetty, and some accessory structures for piping and wiring will need to be constructed.

Purpose	**Time Needed**	**Area Square Feet**	**Rate Per Sq. Ft.**	**Period**	**Cost**
Staging Area A	Once	5,000	$3.00/mo	6 mos	$90,000
Staging Area B	Once	5,000	Nominal	6 mos	$1,000
Plastic Pipe Storage	Summer	6,000	$35.00	Permanent Easement	$210,000
Equip. Walking Area	Year Round	63,000	Nominal	Permanent	$1,000

Only one of the staging areas, A or B, will be utilized and not both A and B. The two sites were selected for possible use for a construction staging area for a one time need. Staging area A is located along a residential area adjacent to the harbor. Staging area B is located on the beach. The above table lists the rate for each site and no determination was made as to which site offers the best use as a staging area.

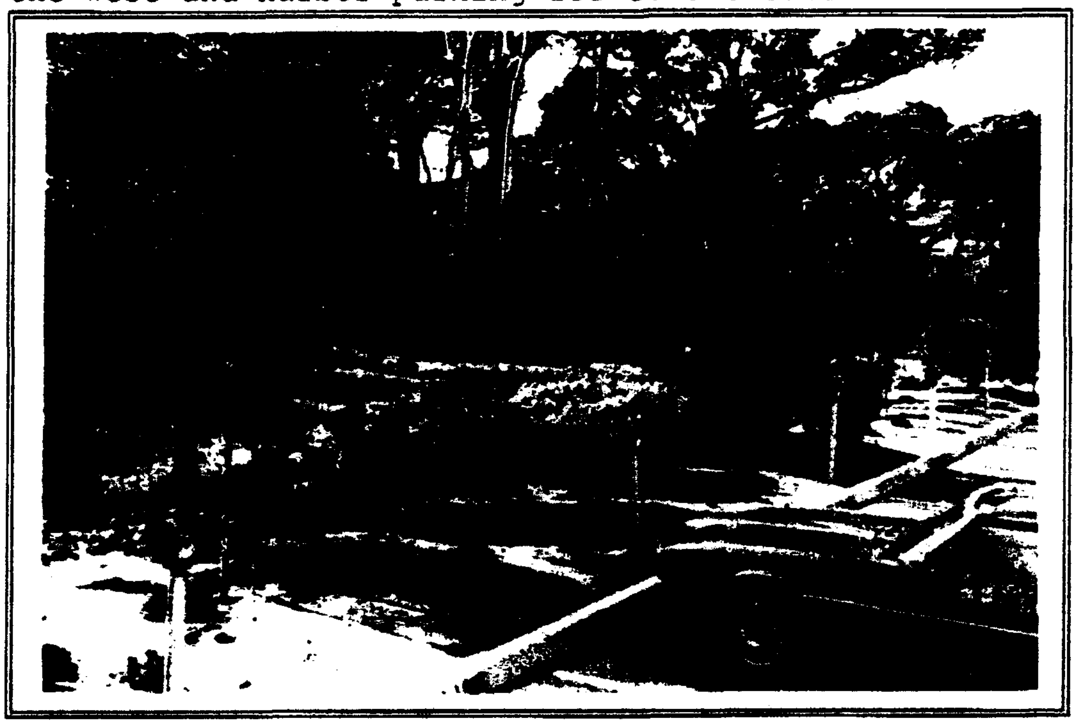
Summer plastic pipe storage would be located in the upper harbor. The plastic pipe would be stored along the visitor parking area and hillside edge. Presently this narrow area is being utilized for rainfall runoff drainage, and could potentially be developed to stackable mini-storage and or extension of existing parking lot.

The equipment walking area would be situated along the existing west jetty. This area is considered to be of nominal value since it is utilized by the public for recreational activities similar to the Twin Lakes Beach area mentioned in the extension of the dredge pipeline scenario.

These locations are illustrated on the following as exhibit B.

PHOTOGRAPHS for Fixed Jet Pump System

Approximate location of staging Area A looking north. Located in the lower harbor in an open area next to residential properties to the west and harbor parking lot to the east.



Additional photo of approximate location of staging area A showing the adjacent harbor parking lot.

PHOTOGRAPHS for Fixed Jet Pump System

Refer to previous photograph under extension of dredge pipeline for view of summer plastic pipe storage area located in the upper harbor.

Approximate location of Staging Area B on the beach. Photo taken from the west jetty locking north west to residential properties in Santa Cruz.

PHOTOGRAPHS for Fixed Jet Pump System

View along west side of west jetty looking north towards Santa Cruz. NOTE how sand has accumulated along the jetty.

12. COST ESTIMATE CONTINUED

MOBILE JET PUMP

This alternative attempts to bypass sand to the east beach before it can accumulate in the harbor. The structures, piping and wiring for this alternative are similar to those of the fixed jet pump. In this scenario, the nozzle will be deployed in the intertidal zone on Seabright Beach. This system would use a jet pump and a 135 ton crawler crane to mine sand off the west beach and pump it to the east beach. The crawler crane would be used to place the jet pump in approved areas well suited for mining. The intent of the system is to create storage areas for sand on the west beach before it travels eastward into the harbor entrance.

Purpose	**Time Needed**	**Area Square Feet**	**Price per Sq. Ft.**	**Estate to be acquired**	**Estimated Cost**
Crane Storage	Summer	5,000	$75.00	Permanent Easement	$375,000
Crane Storage	Winter	5,000	Nominal	Permanent Easement	$1,000
Plastic Pipe Storage	Summer	6,000	$35.00	Permanent Easement	$210,000
Equip. Walking Area	Year Round	63,000	Nominal	Permanent Easement	$1,000
Mining Area*		80,000	N / A		

The summer crane storage area is the existing dredging operations year round dredge yard which contains approximately 30,000+/- square feet. It is recognized that the crane storage would not require a total of 30,000 square feet and the actual space requirement would be related to the winter space requirement of 5,000 +/- square feet. Therefore for the purposes of this analysis 5,000 +/- square feet has been used as a basis for the amount of square feet needed to store the crane in the summer.

Summer plastic pipe storage would be located in the upper harbor. The plastic pipe would be stored along the visitor parking area and hillside edge. Presently this narrow area is being utilized for rainfall runoff drainage, and could potentially be developed to stackable mini-storage and or extension of existing parking.

*The mining area is located west of the west jetty in the Pacific Ocean and due to this location there is no value of this area due to navigational servitude waters.

These locations are illustrated on the following as exhibit C.

PHOTOGRAPHS for Mobile Jet Pump System

Photo showing the location of the existing dredger operations dredge yard. This area is proposed location for summer crane storage of 5,000 square feet.

The winter crane storage photo is located above as staging area B for the fixed jet pump.

Refer to photograph under extension of dredge pipeline for view of summer plastic pipe storage area located in the upper harbor.

The equipment walking are is shown in the photo for the fixed jet pump system, and is the view of the west side of the west jetty.

The mining area was not photographed as it is in the Pacific Ocean.

COST ESTIMATE SUMMATION

EXTENSION OF DREDGE PIPELINE

Land	
Summer Plastic Pipe Storage Estimated Value	$210,000
Winter Plastic Pipe Storage Estimated Cost	$ 1,000
Improvements	$ 0
There are no improvements that will be affected by the permanent easements.	
Contingencies 25% of land and improvements	$ 52,750
Severance Damages	$ 21,100
Relocation Costs (PL 91-646)	$ 0
There are no residences or businesses located on the proposed permanent easement sites.	
Total estimated cost for dredge pipeline extension	$285,850
Rounded to	**$285,000**

FIXED JET PUMP

Land	
Staging Area A Estd one time lease value	$ 90,000
Staging Area B Estd one time lease cost	$ 1,000
Summer Plastic Pipe Storage Estimated Value	$210,000
Equipment Walking Area Estimated Cost	$ 1,000
Improvements	$ 0
No improvements will be affected by the one permanent easement for the walking area or either staging areas.	
Contingencies 25% of land and improvements	$ 75,500
Severance Damages	$ 30,200
Relocation Costs (PL 91-646)	$ 0
There are no residences or businesses located on the proposed staging sites or walking area.	
Total estimated cost for fixed jet pump system	$407,700
Rounded to	**$410,000**

MOBILE JET PUMP

Land	
Summer Crane Storage Estimated Value	$375,000
Winter Crane Storage Estimated Value	$ 1,000
Summer Plastic Pipe Storage Estimated Value	$210,000
Equipment Walking Area Estimated Value	$ 1,000
Improvements No improvements will be affected by the permanent storage easements or the equipment walking area.	$ 0
Contingencies 25% of land and improvements	$146,750
Severance Damages	$ 58,700
Relocation Costs (PL 91-646) There are no residences or businesses located on the proposed permanent easement sites or equipment walking area.	$ 0
Subtotal estimated cost for mobile jet pump system	$792,450
Rounded to	**$800,000**

13. CERTIFICATION

I hereby certify that the statements of fact upon which the opinions herein are based are true and correct and the cost estimates as developed for the temporary work, storage and staging areas represent to the best of my knowledge and belief, my unbiased opinion and judgement, subject to the assumptions and limiting conditions stated in the report.

Employment in and compensation for making this cost estimate is in no way contingent upon the values reported, and I certify that I have no interest, either present or contemplated, in the Santa Cruz Harbor property. I have no personal interest or bias with respect to the subject matter of the cost estimate report or the parties involved.

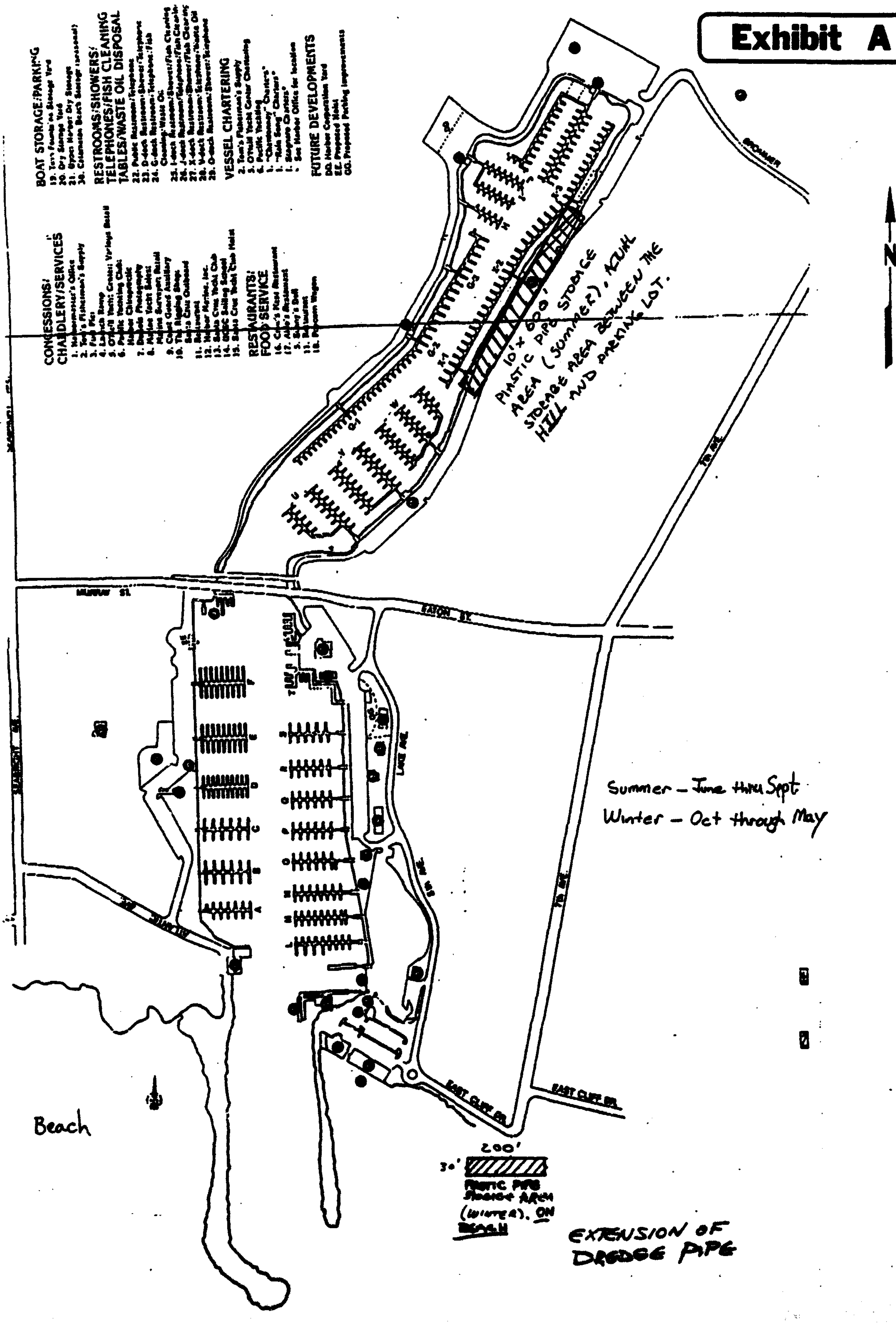
Dated: 31-March-92

Brian Kirchner

Brian Kirchner
Appraiser

EXHIBITS

Exhibit A



CONCESSIONS/ CHANDLERY/SERVICES
RESTAURANTS/ FOOD SERVICE
BOAT STORAGE/PARKING
RESTROOMS/SHOWERS/ TELEPHONES/FISH CLEANING TABLES/WASTE OIL DISPOSAL
VESSEL CHARTERING
FUTURE DEVELOPMENTS
10'x 600' PLASTIC PIPE STORAGE AREA (SUMMER). ALONG STORAGE AREA BETWEEN THE HILL AND PARKING LOT.
N
MURRAY ST.
EATON ST.
LAKE AVE.
5TH AVE.
7TH AVE.
EAST CLIFF DR.
Summer – June thru Sept
Winter – Oct through May
Beach
200'
30'
PLASTIC PIPE STORAGE AREA (WINTER). ON BEACH
EXTENSION OF DREDGE PIPE

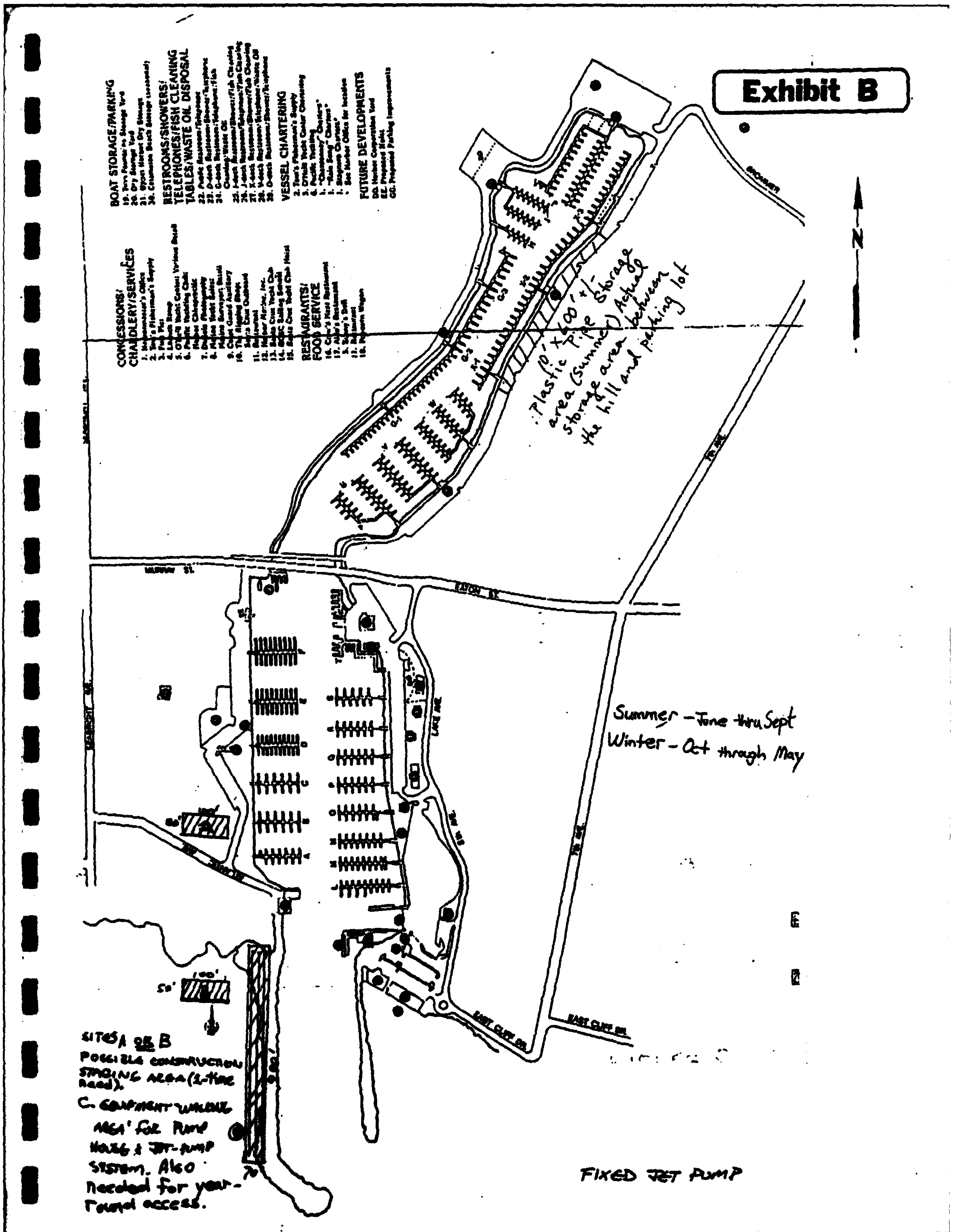
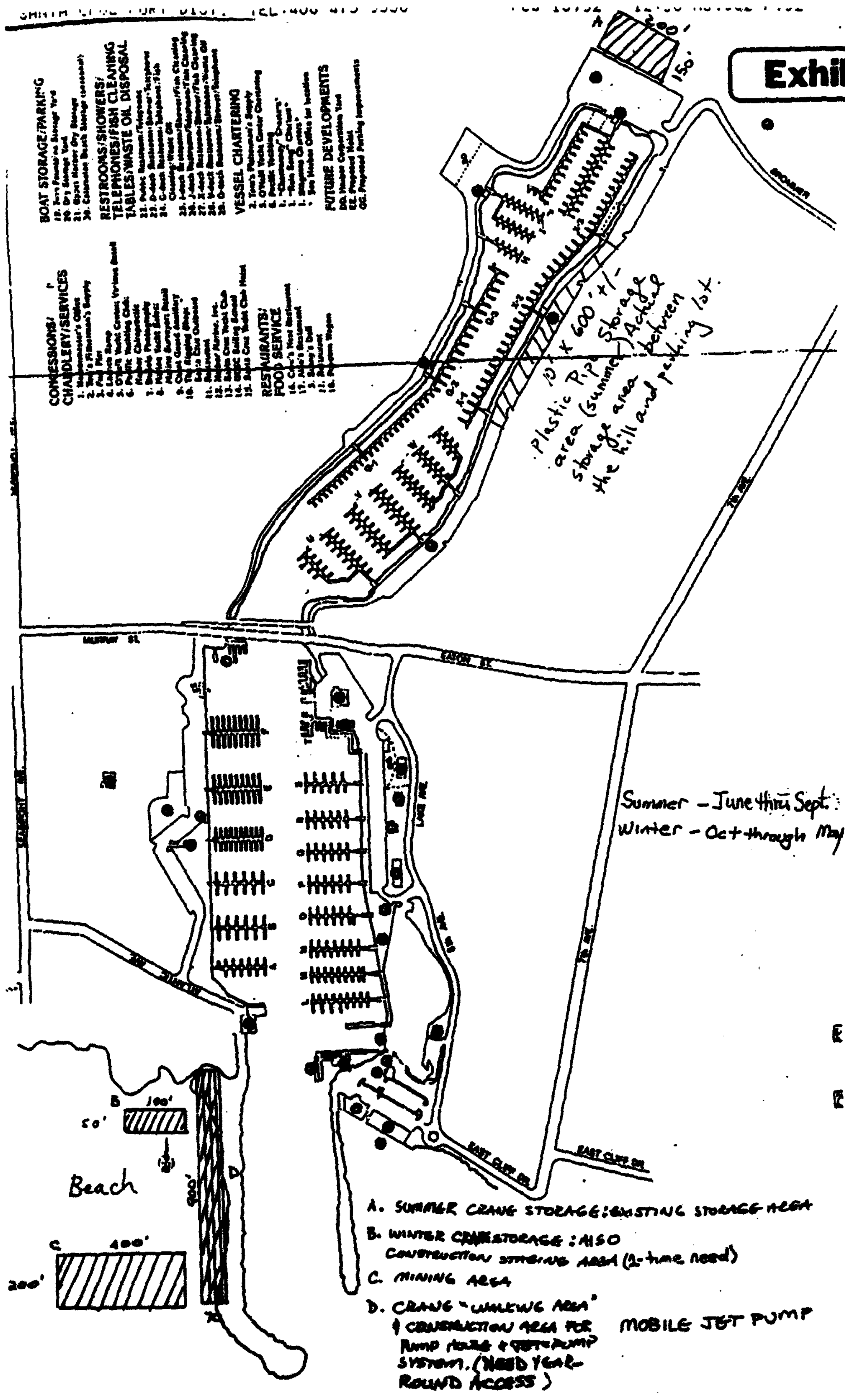


Exhibit B
BOAT STORAGE/PARKING
RESTROOMS/SHOWERS/
TELEPHONES/FISH CLEANING
TABLES/WASTE OIL DISPOSAL
VESSEL CHARTERING
FUTURE DEVELOPMENTS
CONCESSIONS/
CHANDLERY/SERVICES
RESTAURANTS/
FOOD SERVICE
MURRAY ST.
EATON ST.
LAKE AVE.
EAST CLIFF DR.
Plastic 10' x 600' +/- Pipe storage area (Summer) Actual storage area between the hill and parking lot
Summer - June thru Sept
Winter - Oct through May
50'
100'
SITES A OR B
POSSIBLE CONSTRUCTION STAGING AREA (1-time need).
C. EQUIPMENT WAREHOUSE AREA FOR PUMP HOUSE & JET-PUMP SYSTEM. Also needed for year-round access.
FIXED JET PUMP

Exhibit C



A 200'
150'
N
MURRAY ST.
EATON ST.
LAKE AVE.
EAST CLIFF DR.
10' x 600' +/-
Plastic Pipe Storage area (summer) Actual storage area between the hill and parking lot.
Summer - June thru Sept.
Winter - Oct through May
B 100'
50'
Beach
C 400'
200'
900'
D
A. SUMMER CRANE STORAGE: EXISTING STORAGE AREA
B. WINTER CRANE STORAGE: ALSO CONSTRUCTION STAGING AREA (1-time need)
C. MINING AREA
D. CRANE "WALKING AREA" & CONSTRUCTION AREA FOR PUMP HOUSE & JET PUMP SYSTEM. (NEED YEAR-ROUND ACCESS)
MOBILE JET PUMP